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ABSTRACT

Intended for use in the technical program of a technical institute or community college, this student manual is designed to provide background in the metric system contributing to employability. Nine units are presented with objectives stated for each unit followed by questions or exercises. (Printed answers are supplied when necessary.) Unit 1 introduces metric definitions, a rationale for the change to metrics, and the basic mathematical units used. Unit 2 presents the use of prefixes and symbols, and explains spellings and the writing of numbers in the metric system. Units 3 through 9 present lessons on temperature (kelvin and Celsium scales), linear measure (kilometre, metre, decimetre, centimetre, and millimetre), building technology (metric tools and standards), area (square kilometre, square metre, square decimetre, square centimetre and square millimetre), volume (cubic metre, cubic decimetre, cubic centimetre), mass or weight (kilogram), and tire pressure, speed, and horsepower (kilopascal, kilometre per hour, and kilowatt). (BL)

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Division of Vocational Education

THE SI METRIC SYSTEM AND PRACTICAL APPLICATIONS

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To the Student

If you were given a nail and a 2 X 4 and asked to pound the nail into this piece of lumber, it is highly unlikely that you would be successful without the aid of the proper tool. If someone gave you a hammer, the task would become a rather simple routine.

If you were asked to calculate the number of cubic meters of concrete for a foundation or concrete slab, or to find the number of bricks to use for a wall, or the number of litres of paint to buy in order to paint a room, you probably would not be successful unless you possess a certain tool. The purpose of this book will be to give you the "tool" of basic mathematics. Even though you cannot touch it or purchase it at a nearby store, you will find that it will be just as important as – if not more important than – any of your other tools. It has been said that mathematics is the most integrating factor in the physical world.

President Gerald R. Ford signed the Metric Conversion Act (Public Law 94-168) on December 23, 1975. According to this law, the United States is now engaged in a voluntary changeover to the metric system of weights and measures. The principal objective of this textbook is to give you a background in the metric system, so that you will be employable in the future. Hopefully after completing this, you will welcome the changeover.

Often in discussing the teaching and learning of the metric system, the question of *conversion* arises. The author believes that conversions should not be used in teaching the metric system. Instead, a person should have as many "hands on" experiences with metric units of measure as are possible.

The mention of customary units will therefore be kept to an absolute minimum. If any are mentioned, then only very general words of comparison will be used, such as "smaller," "larger," "almost the same."

Many people know that 1 inch equals 2.54 centimetres. Then they can say that they know the *conversion factor* from inches to centimetres – but they cannot say that they know the *metric system*. In those cases where conversions are really needed, tables are available.

TABLE OF CONTENTS

Page

To the Student i

UNIT I – INTRODUCTION

Lesson 1 – Definitions 1
Lesson 2 – Customary Units 3
Lesson 3 – Why Metric? 6
Lesson 4 – Multiplication and Division by Powers of 10 12

UNIT II – METRIC PRACTICES

Lesson 1 – The Prefixes 18
Lesson 2 – The Symbols 20
Lesson 3 – "RE" and "ER" Spellings 23
Lesson 4 – Writing Numbers 25

UNIT III – TEMPERATURE

Lesson 1 – Celsius and Kelvin 27
Lesson 2 – Degrees Celsius 29

UNIT IV – LINEAR MEASURE

Lesson 1 – Units of Length 34
Lesson 2 – Conversion Within SI Units of Length 36
Lesson 3 – Measuring and Estimating in Units of Length 43
Lesson 4 – Diameter, Radius, Circumference 48
Lesson 5 – Metric Micrometer 53
Lesson 6 – Metric Vernier Caliper 57

UNIT V – METRICS IN BUILDING TECHNOLOGY

Lesson 1 – Metric Tools 61
Lesson 2 – Metric Standards 64

UNIT VI – AREA

Lesson 1 – Units of Area 65
Lesson 2 – Conversions Within SI Units of Area 67
Lesson 3 – Area of a Rectangle, Triangle, and Trapezoid 71
Lesson 4 – Area of a Circle 77
Lesson 5 – Lateral Surface Area 81

UNIT VII – VOLUME

Lesson 1 – Units of Volume 83
Lesson 2 – The Litre 88
Lesson 3 – Conversions Within Units of Volume 91
Lesson 4 – Volume of Rectangular Box and Cube 96
Lesson 5 – Volume of a Right Prism and a Right Circular Cylinder . . 100

UNIT VIII – MASS OR WEIGHT

Lesson 1 – Units of Mass or Weight 105
Lesson 2 – Conversions Within Units of Mass or Weight 108
Lesson 3 – Estimation and Mathematical Problems With Units of Mass or Weight 110

UNIT IX – TIRE PRESSURE, SPEED, HORSEPOWER

Lesson 1 – Tire Pressure 113
Lesson 2 – Speed 115
Lesson 3 – Horsepower 117

Appendix – British Standards for Lumber 120

UNIT I – INTRODUCTION

Lesson 1 **Definitions**

Objectives:

1. You should be able to explain what is meant by the term "customary system."

2. You should be able to explain what is meant by the term "International System of Units" (SI).

3. You should be able to explain the meaning of the abbreviation SI.

The **customary system** refers to the system of weights and measures that is predominantly being used in the United States. The inch, foot, yard, quart, gallon, and pound are a few of the units used in this system.

Prior to 1960 there were several "dialects" of the metric system being used throughout the world. The differences between these dialects were very subtle and only affected work of a highly precise nature. Nevertheless, it was felt that a truly international metric system was needed so that all would speak the identical metric language. Therefore, in 1960, at the 11th General Conference of Weights and Measures (CGPM), a practical system of measurement for international use was accepted.

The system was founded on six base units: the **metre** (length), the **kilogram** (mass), the **second** (time), the **ampere** (electric current), the **degree Kelvin*** (thermodynamic temperature), and the **candela** (luminous intensity). The name given to this system is the "International System of Units." The international abbreviation for this name is SI. Any reference to the metric system in this text will mean the SI units.

At the 14th CGPM in 1971 the seventh base unit was accepted. It was decided that the **mole** would become the base unit for amount of substance.

The remainder of the units in the SI system are either *derived* or *supplementary units*. The derived units are those formed by combining base units according to the rules of algebra. For example, the **square metre** is a derived unit. The supplementary units are those which are neither base units nor derived units. For example, the radian, a measure for angles, is a supplementary unit. Other units which are not SI, but are recognized by SI, will be used in this text. Two examples would be the degree Celsius, a unit of temperature, and the litre, a measure of volume used for liquids.

* The degree Kelvin was changed in 1967 to the simple name kelvin.

Questions:

1. From memory, write the meaning of the term "customary system."
2. From memory, write the meaning of the term "International System of Units."
3. What do the letters "SI" stand for?
4. What are the three types of units used in the International System of Units?

UNIT I – INTRODUCTION

Lesson 2 — **Customary Units**

Objectives:

1. You will become aware of how well you know the customary units.
2. You should be able to explain why the customary system is difficult to remember.

The following list contains examples of some of the customary units. For each of the units, give an equivalent weight or measure. Example 1 foot = 12 inches.

Length

1 yard =
1 rod =
1 furlong =
1 mile =
3 miles =

Area

1 acre =
640 acres =

Volume

1 cubic foot =
1 cubic yard =
1 board foot =
1 cord =

Liquid Measure

1 quart =
1 pint = ____ gills
1 gallon =
1 barrel (oil) =

Dry Measure

2 pints =
8 quarts =
1 bushel =

Avoirdupois Weight

$27\frac{11}{32}$ grains =
1 ounce =
1 pound =
1 ton =

Troy Weight

1 pound =

Fluid Ounces

1 pint = ___ fluid ounces
1 quart = ___ fluid ounces
1 gallon = ___ fluid ounces

The answers to the above will be found at the end of this lesson.

One of the criticisms of the customary system is the *difficulty of remembering* the actual names of the units, their meanings, and their relationship to each other.

First let's examine the words we use for the customary units. For example, What does the spelling of the word "foot" have to do with the spelling of the word "yard"? Is there any logical way to derive one from the other without memorization? How about "quart," "pint," "gallon," and "barrel"? Or "peck," "quart," and "bushel"? Is there any logic to their spellings? One conclusion that can be drawn about the choice of the spellings of the words in the customary system is that they are extremely random, unrelated, unorganized, illogical, and just plain confusing. Knowing the spelling of one word does not help a person to spell any of the others. In the metric system we will find a definite, logical pattern to the spellings of many units. Also we find that the *multiples* are very inconsistent in the customary system. For example, there are *12* inches in a foot, *3* feet in a yard, *5280* feet in a mile, *2* pints in a quart, *4* quarts in a gallon, *16* ounces in a pound, *2000* pounds in a ton, and so on.

Each individual weight or measure in the customary system must be memorized. Unfortunately, we tend to forget things that we have memorized when we do not use them often.

Questions:

1. From memory, give an equivalent weight or measure for each of the customary units in the list on page 3.

2. State three reasons why the units in the customary system are difficult to remember.

ANSWERS

Length

1 yard =	3 ft. or 36 in.
1 rod =	16½ ft. or 5½ yd.
1 furlong =	660 ft. or 1/8 mile
1 mile =	5,280 ft.
3 miles =	15,840 ft. or 1 league

Area

1 acre =	43,560 sq. ft.
640 acres =	1 sq. mile

Volume

1 cubic foot =	1,728 cu in.
1 cubic yard =	27 cu. ft.
1 board foot =	144 cu. in.
1 cord =	128 cu. ft.

Liquid Measure

1 quart =	2 pints
1 pint =	4 gills
1 gallon =	4 quarts
1 barrel (oil) =	42 gallons

Dry Measure

2 pints =	1 quart
8 quarts =	1 peck
1 bushel =	4 pecks or 32 qt.

Avoirdupois Weight

$27\frac{11}{32}$ grains =	1 dram
1 ounce =	437.5 grains
1 pound =	16 ounces
1 ton =	2000 lbs.

Troy Weight

1 pound =	13.166 oz. Avoirdupois

Fluid Ounces

1 liquid pint =	16 fluid ounces
1 liquid quart =	32 fluid ounces
1 gallon =	128 fluid ounces

Lesson 3 — Why Metric?

Objectives: You should be able to state four reasons why the U.S. decided to change to the metric system.

From 1817 to 1821, John Quincy Adams made the first study for Congress, investigating the question of the advantages and disadvantages of the metric system and whether or not the U.S. should adopt it.

Since the Adam's study there have been many, many arguments presented, both for and against the adoption of the metric system. The United States government publication, "A Metric America, A Decision Whose Time Has Come," states that the metric controversy is "perhaps the longest running debate in the history of this country."

As was stated in the preface, President Ford signed the Metric Conversion Act (Public Law 94-168) on December 23, 1975. Let's explore some of the reasons why the United States finally decided to change over to the metric system.

One of the most basic reasons is the *simplicity of the system itself.* For example, the metric system uses the decimal system, which is the same as the decimal base of our monetary system. It is easier to do arithmetic computations with decimals than it is with common fractions. Furthermore, the electronic hand calculator, which has become an almost indispensable tool, uses the decimal system exclusively. The following two examples should illustrate the fact that decimals are easier to work with than common fractions.

Example 1: Suppose we wanted to make a sign saying "SALE." We have available a set of stencils that we can use to make the letters.

To make a professional-looking sign we want the letters to be *equally spaced.*

a. We make the following measurements:

Width of the sign	$22\frac{1}{4}$
Width of the letter S	$3\frac{3}{8}$
Width of the letter A	$4\frac{7}{8}$
Width of the letter L	$3\frac{7}{8}$
Width of the letter E	$4\frac{1}{4}$

b. Add the widths of S, A, L, and E together:

$$3\frac{3}{8} + 4\frac{7}{8} + 3\frac{7}{8} + 4\frac{1}{4}$$

Re-write the fractions with a common denominator:

$$3\frac{3}{8} + 4\frac{7}{8} + 3\frac{7}{8} + 4\frac{2}{8}$$

Add the whole numbers and the numerators of the fractions:

$$14\frac{19}{8}$$

Change the improper fraction to a proper fraction:

$14 + 2\frac{3}{8} = 16\frac{3}{8}$ (Total width of four letters)

c. Subtract from the width of the board to find the total measure of blank space:

$$22\frac{1}{4} - 16\frac{3}{8}$$

Re-write the fractions with a common denominator :

$$22\frac{2}{8} - 16\frac{3}{8}$$

Borrowing 1 from 22, we have:

$$21\frac{10}{8} - 16\frac{3}{8}$$

Subtracting, we get:

$5\frac{7}{8}$ (Total width of blank spaces)

d. Now the letters, S, A, L, E were to be placed evenly, so $5\frac{7}{8}$ must be divided by 5 (the number of spaces before, after, and between).

$$5\tfrac{7}{8} \div 5$$

Dividing the whole number:

$$5 \div 5 = 1$$

Dividing the fractional part:

$$\tfrac{7}{8} \div 5 = \tfrac{7}{8} \cdot \tfrac{1}{5} = \tfrac{7}{40}$$

Therefore, each space should be $1\frac{7}{40}$ of an inch!

Upon grabbing a ruler, we encounter a real problem. Where is $1\frac{7}{40}$ of an inch located? More work!

$$\tfrac{7}{40} \text{ of an inch} \quad \text{or} \quad \tfrac{7}{40} \cdot 1 \text{ inch}$$

Suppose we try to convert $\frac{7}{40}$ to sixteenths of an inch. There are 16 16ths in an inch. How many is $\frac{7}{40}$ of the 16?

$$\tfrac{7}{40} \cdot \tfrac{16}{1} = \tfrac{7}{\cancel{40}_{5}} \cdot \tfrac{\cancel{16}^{2}}{1} = \tfrac{14}{5} = 2\tfrac{4}{5} \text{ sixteenths}$$

Therefore, each space should be a little less than $1\frac{3}{16}$ inches.

Let's try the same problem over again, using the metric system.

a. Make the following measurements:

Width of the sign	565 mm
Width of the letter S	86 mm
Width of the letter A	124 mm
Width of the letter L	98 mm
Width of the letter E	108 mm

b. Add the widths of S, A, L, E together:

$$\begin{array}{r} 86 \text{ mm} \\ 124 \text{ mm} \\ 98 \text{ mm} \\ \underline{108 \text{ mm}} \\ 416 \text{ mm} \end{array}$$

c. Subtract to find the total measure of blank space:

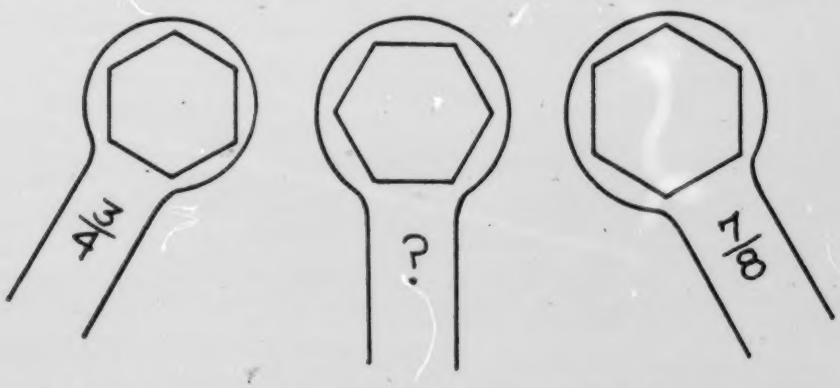
$$\begin{array}{r} 565 \text{ mm} \\ \underline{416 \text{ mm}} \\ 149 \text{ mm} \end{array}$$

d. Divide by 5 (the spaces before, after, and between).

$$149 \div 5 = 29.8 \text{ mm for each space}$$

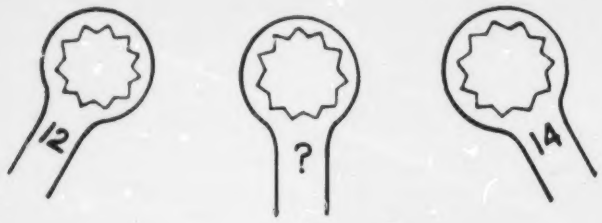
It will be no problem to locate a point just a little under 30 mm on a metric ruler.

Example 2: Suppose you were working on a car and you tried the $\frac{3}{4}$ inch wrench (on the left) and found it to be too small. Then you tried the $\frac{7}{8}$ inch wrench (on the right) and found it to be too large. What size would you try next?



If it took you more than one-tenth of a second to figure out the answer (which is 13/16), try a similar situation with the metric system.

Suppose you tried the 12mm wrench (on the left) and found it too small. Then you tried the 14mm wrench (on the right) and found it too large. What size would you reach for next?



If a student is not a lover of fractions and least common denominators, the metric system should be extremely attractive. Even those who do love fractions will have to admit the metric system is a lot faster – as shown by the above problems.

Next we will compare the work involved with *conversions within each system.*

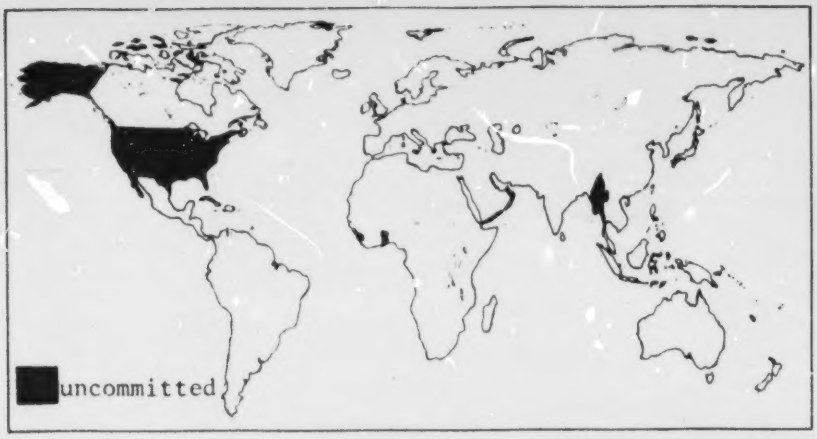
Suppose you had a measurement of 13¾ feet and needed to change this to inches. Or suppose you knew that a certain distance was 1205 feet and wanted to know what part of a mile it was. What would the answers be? You try it. . . . . How long did it take you to get the *right* answers?

Let's compare these with the same types of problems in the metric system. Suppose we had 13.75 metres and needed to change this to centimetres. And suppose we had 1205 metres to change to kilometres.

13.75 metres = 1375 centimetres
1205 metres = 1.205 kilometres

The only work that had to be done was to move the decimal point. By the time you are half-way through this book you should be able to do these two problems in the metric system in a matter of 10 seconds or less.

Another advantage of the metric system is that it *keeps memorization to a minimum.* The base words and the prefixes form a very logical pattern. The use of a certain prefix actually tells us a word's meaning. There is some memorization in the metric system, but, as you will see, there is certainly less than in the customary system.



The map shown here gives us a feel for the United States' position in the world before it committed itself to the metric system. The United States was the last major industrial country in the world to decide to go metric. The rest of the major countries had all previously committed themselves to the truly international language of weights and measures. This fact certainly made an impact on the United States' position in international trade.

In the early 1970's, this impact was still not too great. Certain exports – grains, for example – were not measurement-sensitive. In other areas, such factors as reputation, reliability of products, superior technology, high quality, and competitive pricing tended to outweigh the adverse effects of the nonmetric standards for machinery and their parts. These factors have lost some of their importance, however, as metric countries' technologies have advanced to U.S. levels.

Furthermore, the European Economic Community (EEC) has stated that it will require the use of certain SI units in all trade beginning December 31, 1977. Australia and New Zealand are also following this example. Therefore, the *economic gains and the jobs saved* must be considered as another reason for the changeover.

Questions:

State four reasons why the United States decided to change to the metric system.

Lesson 4 — Multiplication and Division by Powers of 10

Objectives:

1. You should be able to raise the number 10 to any indicated power.
2. You should be able to write any multiple of 10 as the number 10 with the appropriate exponent.
3. You should be able to multiply and divide by multiples of ten by simply moving the decimal point.
4. You should be able to recognize scientific notation.

An *exponent* tells us *how many times to use the base number as a factor.* In the expression 10^5, 10 is the base number and 5 is the exponent. The word *factor* implies the operation of *multiplication.*

Therefore,

$$10^5 \text{ means } 10 \times 10 \times 10 \times 10 \times 10 = 100\,000$$

Notice that the base number 10 was used 5 times in the operation of multiplication.

Another way of describing 10^5 is to say 10 raised to the 5th *power.*

10^1 means 10
10^2 means $10 \times 10 = 100$
10^3 means $10 \times 10 \times 10 = 1000$
10^4 means $10 \times 10 \times 10 \times 10 = 10{,}000$

If we have the base number 10 and a positive exponent, this can be written as a 1 followed by *the number of zeros indicated by the number in the exponent.* Check the above examples in order to verify this statement.

If you wished to write some multiple of 10 as the base number 10 with an exponent, then you would simply count the number of zeros after the 1 and use this number as the exponent.

Example:

$1\,000\,000 = 10^6$
$1\,000 = 10^3$
$100 = 10^2$
$10 = 10^1$

Now perform the following multiplications:

10	15	31.5	33.22
× 5	× 10	× 10	× 10
100	21.3	22.517	
× 3	× 100	× 100	
1000	2.531	79.317	
× 43	× 1000	× 1000	

What can we say about the decimal point when we multiplied a number by 10? by 100? by 1000? What do you think would happen to the decimal point if we multiplied by 10 000? by 100 000? by 1 000 000? What generalization does this lead us to?

Just as easily as we can multiply by 1000 or 1 000 000 by moving the decimal point, we can multiply by 10^3 or 10^6. In a way it is even easier: we don't have to count the zeros. They have already been counted for us.

For example, $1.927 \times 10^2 = 192.7$ (Decimal point moved *2* places to the right)

$0.13456 \times 10^3 = 134.56$ (*3* places to the right)

$1.6406 \times 10^4 = 16\,406.$ (*4* places to the right)

Now suppose you have to multiply a number like 37.89 by 10^3. You must move the decimal point 3 places to the right. But you have only *2* places after the decimal point. In such a case you must *add a zero* to get the correct number of places.

$37.89 \times 10^3 = 37890 = 37\,890$

Another example:

$$40 \times 100 = 4000 = 4\,000$$

(Of course for this last example you must remember that the number 40 has a decimal point *understood* after the number.)

Now perform the following divisions:

$10\overline{)2.0}$ $10\overline{)70}$ $10\overline{)852.1}$ $10\overline{)3.72}$

$100\overline{)5.00}$ $100\overline{)57.61}$ $100\overline{)352.763}$

$1000\overline{)14.2}$ $1000\overline{)451.2326}$

What can we say about the decimal point of a number when we divide it by 10? by 100? by 1000? What do you think would happen to the decimal point if we divided by 10 000? by 100 000? by 1 000 000? What generalization does this lead us to?

Once again, when dividing mentally by powers of 10, you may have to add one or more zeros to get the decimal point in the right place. And you must remember the understood decimal at the end of a whole number.

$$0.92 \div 100 = 0.0092$$
$$1.04 \div 1000 = 0.00104$$
$$240 \div 1000 = 0.240$$

(Notice that we have inserted an *extra* zero in front of the decimal point. In the metric system this is always done. As you know, it does not change the value of the number, but it does emphasize the location of the decimal point.)

We saw above that a number like 10^3 was a short way of writing $10 \times 10 \times 10$. Similarly, there is a short way of writing $\frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$. It is 10^{-3}. Still another way of writing the same thing is $\frac{1}{10^3}$. A fourth way is $\frac{1}{1000}$. And a fifth way is .001.

Another example of a *negative exponent:*

$$10^{-4} = \frac{1}{10^4} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = \frac{1}{10{,}000} = .0001$$

We saw above how to multiply a number by a power of 10:

$$652 \times 10^2 = 65\,200$$

To multiply 652 by 10^{-2}:

$$652 \times 10^{-2} = \frac{652}{10^2} = 100\overline{)652.00}\ \ 6.52$$

Comparing our answer, 6.52, with our original number, 652, we see that we multiplied by 10^{-2} by moving the decimal point *two places to the left.*

Similarly, $36.21 \times 10^{-3} = 36.21 \div 1000$

or

$$1000\overline{)36.21000}\ \ .03621$$

Again, we multiplied by 10^{-3} by moving the decimal point *three places to the left.*

We observed above that there is a quick way of changing back and forth between a number expressed as a *power of ten* and the same quantity expressed in the more usual way. *The exponent is always equal to the number of zeros after the 1.*

$10^5 = 100\,000$ (5 zeros)

There is an equally quick way of converting numbers with negative exponents to the more usual form. *The exponent is one less than the number of zeros between the decimal point and the 1.*

$10^{-5} = 0.000\,01$ (4 zeros)

$10^{-7} = 0.000\,000\,1$ (6 zeros)

Although in everyday life we do not see many expressions like 10^4 or 10^{-6}, they are used all the time in scientific work. For example, the velocity of electromagnetic waves through space is 3×10^8 metres per second. In electronics, you might have an inductance of 2.7×10^{-4} henrys, or a capacitance of 3.5×10^{-8} farads. Expressing very large and very small quantities this way makes calculating much easier. This way of writing numbers is called *scientific notation.*

Problems: Express the following quantities in another way:

Example: $10^7 = 10\ 000\ 000$

1. 10^6 = _____
2. 10^4 = _____
3. 10^{-2} = _____
4. 10^{10} = _____
5. 10^{-4} = _____
6. 10^2 = _____
7. 10^{-1} = _____

Example: $100 = 10^2$

8. $1\ 000\ 000$ = _____
9. 1000 = _____
10. 0.0001 = _____
11. $0.000\ 001$ _____

In the following problems, perform the operations indicated:

Example: $1000 \times 45.2 = 45\ 200.$

12. 100×5 = _____
13. 0.321×1000 = _____
14. 10×0.05 = _____
15. $0.7321 \times 1\ 000\ 000$ _____
16. 46.732×10^4 = _____
17. $0.003\ 21 \times 10^3$ = _____
18. 1.213×10^2 = _____
19. 132.71×10 = _____

Example: $43.21 \div 1000 = 0.04321$

20. $326.71 \div 100$ = _____
21. $46{,}002 \div 10\ 000$ = _____
22. $0.132 \div 10$ = _____
23. $4359 \div 1\ 000\ 000$ = _____
24. 876×10^{-3} = _____
25. 17.89×10^{-2} = _____

26. 0.013×10^{-1} = _____

27. 3215.7×10^{-6} = _____

Work out the following problems and express the answers in terms of powers of 10.

28. $10^{3} \times 10^{2}$ = _____

29. $10^{7} \times 10^{-3}$ = _____

30. $10^{-2} \times 10^{-2}$ = _____

UNIT II – METRIC PRACTICES

Lesson 1 — **The Prefixes**

Objectives:

1. You should know how many SI prefixes there are.

2. You should memorize the spellings and the meanings of the five commonly used prefixes.

A prefix is a group of letters attached to the beginning of a word. In the SI metric system there are 16 prefixes. Most of them are not used in everyday transactions. Some are used only by scientists in dealing with very large and very small quantities.

SI Prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{18}	exa	E	10^{-1}	**deci**	**d**
10^{15}	peta	P	10^{-2}	**centi**	**c**
10^{12}	tera	T	10^{-3}	**milli**	**m**
10^{9}	giga	G	10^{-6}	micro	μ
10^{6}	**mega**	**M**	10^{-9}	nano	n
10^{3}	**kilo**	**k**	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10	deka	da	10^{-18}	atto	a

Mega, kilo, deci, centi, and *milli* are the most commonly used prefixes.

Mega and *kilo* are used for large multiples of the units. For example:

megahertz means 1 000 000 hertz
megagram means 1 000 000 grams
megaton means 1 000 000 tons

kilogram means 1000 grams
kilometre means 1000 metres
kilowatt means 1000 watts

Deci, centi, and *milli* are used for decimal (fractional) parts of the units. For example:

decimetre means one-tenth or 1/10 or .1 of a metre
centimetre means one-hundredth or 1/100 or .01 of a metre
millimetre means one-thousandth or 1/1000 or .001 of a metre
millilitre means one-thousandth or 1/1000 or .001 of a litre

Memory hints:

deci – dime	1/10 or .10 of a dollar
centi – cent	1/100 or .01 of a dollar
milli – mill	1/1000 or .001 of a dollar

It is not proper to use a prefix without a unit in either writing or speech. Say "kilogram," not "kilo."

In Europe we hear "kil LOM i tre" instead of "KIL o metre." It should be clear that in the United States we will be saying "KIL o metre." The accent for *all* prefixes is on the first syllable.

Questions:

1. How many SI prefixes are there?
2. What are the five most commonly used prefixes?
3. Write the five most commonly used SI prefixes and their meanings from memory.
4. Say the word "kilometre" two ways. Which one will be used in the United States?

Lesson 2 **The Symbols**

Objectives:

1. You should memorize the proper SI symbols for some commonly used units.

2. You should be able to identify correct and incorrect symbols.

In the United States we often use abbreviations for units in the customary system. For example, we write "mi." for mile, "hr." for hour, etc.

The International System of Units does not have abbreviations, but instead uses symbols to stand for the units.

In order to continue, we should memorize the following symbols.

Unit	Symbol
kilometre	km
metre	m
centimetre	cm
millimetre	mm
kilogram	kg
gram	g
milligram	mg
litre	l or ℓ or L*
millilitre	ml

There are some important rules which apply to the use of symbols.

* The International Committee of Weights and Measures (CIPM) at its September 1976 meeting rejected the recommendation of the Consultative Committee on Units (CCU) that the upper case L be used as the symbol for litre. At the suggestion of the U.S. National Bureau of Standards, the CCU had in June approved the use of the upper case L.

The General Conference of Weights and Measures which officially established the International System of Units (SI) in 1960 officially recognizes the printed form of the lower case l as the symbol for litre. The same holds true for the International Organization for Standardization (ISO) in its International Standard ISO 1000–1973. Australia, Canada, New Zealand, and South Africa also recognize the script form of lower case ℓ as the symbol for litre, because of the possibility of confusion between l and the number 1.

As of early 1977, indications are that the U.S. National Bureau of Standards will continue to use the upper case L in spite of the decision by CIPM to reject it.

1. *Never use an "s"* to show plural units when using a symbol.
   Examples:

   5 m, not 5 ms
   16 L, not 16Ls
   4 ml, not 4 mls
   7 g, not 7 gs

2. Notice that we are using symbols, not abbreviations. There should be *no periods* used after any of the symbols. Example:

   m, not m.
   5 g not 5 g.
   100 ml, not 100 ml.

   (In a sentence where the measure is spelled out, you would use the plural. For example: "I brought home 2 litres of milk.")

3. The symbols are in general always lower case (small) letters unless they were derived from a proper name. These are capitalized.*
   Examples:

   10 kPa stands for 10 kilopascals, a measure of pressure
   18 N stands for 18 newtons, a measure of force
   22°C stands for a temperature – 22 degrees Celsius

   (Note that *only* "Celsius" is capitalized when written out as a word.)

4. Finally, do not use a symbol within a sentence or phrase unless it is immediately preceded by a figure. You would write, for example, "We drove thousands of kilometres on the trip," not "thousands of km."

Questions:

One of the first places where dual labeling was noticed by the consumer was in the supermarket. Cans, bottles, boxes, etc., often had both customary and metric units on their labels. Unfortunately, many of the metric symbols first being used were wrong. Here is a list found in one supermarket.

a. Identify those which are correct and those which are not.

b. Give the correct symbol for those which are wrong.

c. Check for proper capitalization in the use of unit names.

* But see note on the use of L for litre, on the previous page.

1. gms. _____
2. ml _____
3. Liters _____
4. GRAMS _____
5. ML. _____
6. l _____
7. gm _____
8. LITERS _____
9. g _____
10. Ml _____
11. kg. _____
12. kgs _____
13. gms _____
14. Mls. _____
15. gs _____
16. lts. _____
17. kgms _____
18. grams _____
19. ML _____
20. Grams _____

Choose the correct one of these expressions to fill into each blank.

Metre(s)
metre(s)
m

21. The desk is .75 _____ high.
22. The _____ is an SI unit of length.
23. _____ is a word that was derived from the Greek word metron.
24. The doorway is approximately one _____ wide.
25. The distance across my thumbnail is 0.01 _____ .

UNIT II – METRIC PRACTICES

Lesson 3 — **"RE" and "ER" Spellings**

Objective: You should be able to explain why this textbook uses the spellings "metre" and "litre" instead of "meter" and "liter."

There has been considerable controversy over the "re" vs. "er" endings in the words "metre" (meter) and "litre" (liter).

The official spellings in SI are *metre* and *litre*. In the Federal Register, Vol. 40, No. 119, dated Thursday, June 19, 1975 the National Bureau of Standards states that the U.S. will use *either* the official SI spellings *or* the commonly accepted spellings in this country, "meter" and "liter." The U.S. is the last major industrial country in the entire world to change its system of weights and measures to the SI metric system, but already has decided to ignore the internationally accepted spellings of "metre" and "litre."

In the U.S. Metric Association Newsletter, Vol. 11, No. 1, dated February, 1976, there is a letter from Dr. Jean Terrien, director of the International Bureau of Weights and Measures (BIPM) to Mr. Louis F. Sokol, President of the U.S. Metric Association. In the letter, Dr. Terrien supports a strong desire to "promote international uniformity." The letter also mentions that the spellings "metre" and "litre" have been adopted in South Africa, Australia, Canada, and other English-language countries.

In the U.S. Metric Association Newsletter, Vol. 11, No. 2, dated May 1976, we find two articles on the front page dealing with the "re" spellings.

One article deals with guidelines issued by the Federal Trade Commission (FTC) for permissible labeling practices. In these guidelines we do find the spellings "litre" and "metre," not "liter" and "meter."

The second article concerns the U.S. Department of Transportation, Federal Highway Administration notice N 5190.1 dated March 4, 1976. The purpose of this notice is:

> To inform all Federal Highway Administration and State highway organizations that the spelling for the metric unit of length will be "metre" in all FHWA issuances.

At this writing the U.S. Metric Association strongly supports the "re" endings.

Taking all of this into consideration, the author has decided to use the spellings "metre" and "litre" throughout this text.

Questions:

1. In terms of the "er" and "re" endings, which is accepted by the United States Bureau of Standards?

2. Which ending, "er" or "re", is the true SI spelling?

3. What other meaning does the word "me*ter*" have besides a unit of linear measure?

4. What is the position of other English-speaking countries?

5. Name three national organizations that support the "re" spellings.

Lesson 4 **Writing Numbers**

Objective: You should be able to write numbers correctly according to the SI practices.

1. In writing numbers it is the practice in some countries to use the comma where we use the decimal point. Therefore, to avoid confusion, it is metric practice to *use a space to separate groups of three digits* instead of using the comma.

   Example:

   Write: 531 250.3, not 531,250.3

   An exception to this rule is when there are four digits and the number formed is not in a column with numbers of 5 digits or more.

   Example:

   Write 5200 because the number stands alone.

   But write

   ```
    74 316
    32 819
     5 200
   112 335
   ```

   when in a column with other numbers with more than four digits.

   The rule also holds for decimals. For example,

   Write 3.089 75

2. *Never use common fractions.* Use decimal notation only.

   Write: 0.5 g, not $\frac{1}{2}$ g

3. It is a metric practice to *use a zero preceding a decimal point* when the number is less than 1.

   Write 0.35 kg, not .35 kg

Problems:

Write each of the following using proper metric notation.

1. 13,526 m _____
2. 4,231.5 ml _____
3. 3,526,762 g _____
4. 6541.0029 km _____
5. 10.42756 cm _____
6. $\frac{1}{2}$ mm _____
7. $\frac{1}{4}$ g _____
8. 20,094.68 m _____
9. .2 kg _____
10. .0347 L _____

UNIT III – TEMPERATURE

Lesson 1 — Celsius and Kelvin

Objectives:

1. You should be able to state the name of the SI unit for temperature.

2. You should be able to state the name of the commonly used unit for temperature in the metric system.

3. You should be able to state the relationship between kelvin and Celsius.

An 18th Century Swedish astronomer, Anders Celsius, developed a thermometer based exclusively on the freezing and boiling points of water. He called the freezing point of water 0 degrees and the boiling point 100 degrees. The thermometer based on Celsius' idea was originally called the centigrade thermometer. Recently it was decided to change the name from "centigrade" to "Celsius" in honor of its inventor. At the 13th General Conference on Weights and Measures (CGPM) in 1967, it was decided that temperature intervals may be expressed in degrees Celsius. The symbol for degree Celsius is °C. The degree Celsius is not, however, the official SI unit of temperature.

Lord William Kelvin, a 19th century Englishman, developed a temperature scale based on the Celsius scale that has become the basis for SI temperature. The base unit of this system is the kelvin (notice the small k), which is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. The symbol for this unit is K. The temperature 0 K (zero kelvin) is the temperature at which there could be absolutely no heat, called absolute zero. The kelvin scale is used by certain scientists, but not by the average person in everyday life.

The temperature unit in the kelvin scale and the unit in the Celsius scale are exactly the same size. 0 K is called absolute zero, while 0°C is the freezing point of water. The freezing point of water on the kelvin scale is 273.16.

Scientists may prefer the kelvin scale, but in common, everyday life the Celsius scale will be used.

Questions:

1. What is the name of the SI unit for temperature?

2. What is the symbol for the SI unit for temperature?

3. What is the commonly used unit for temperature which was recognized by the 13th CGPM in 1967?

4. What is the relationship between the size of the unit on the kelvin scale and that on the Celsius scale?

5. Fill in the blanks:

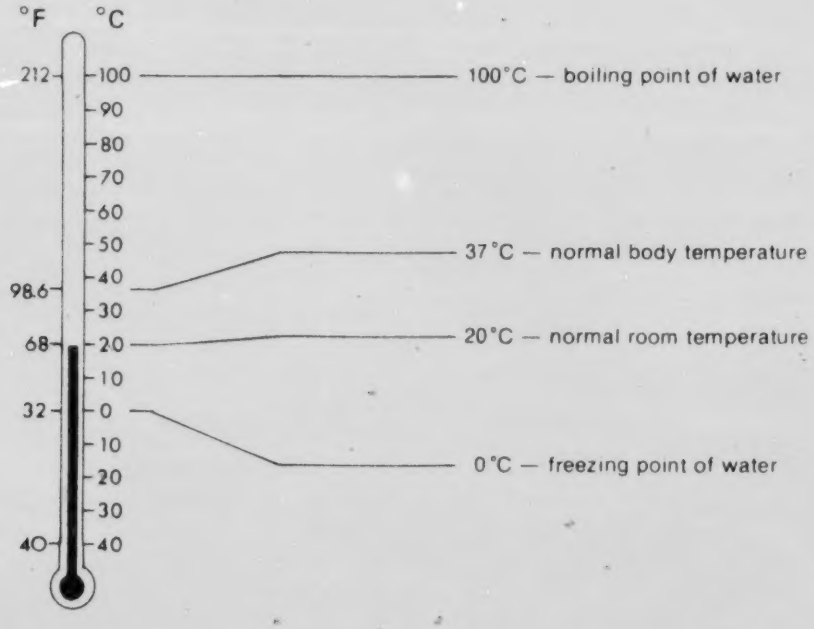
	K	°C
Water boils	_____	_____
Water freezes	_____	_____
Absolute zero	_____	_____

Lesson 2 **Degrees Celsius**

Objectives:

1. You will make a record of inside and outside temperatures in degrees Celsius.
2. You should memorize the freezing point of water, comfortable inside temperature, body temperature, and the boiling point of water in degrees Celsius.
3. You should start to think in degrees Celsius.

The temperature that will be used in everyday situations is the number of degrees Celsius.



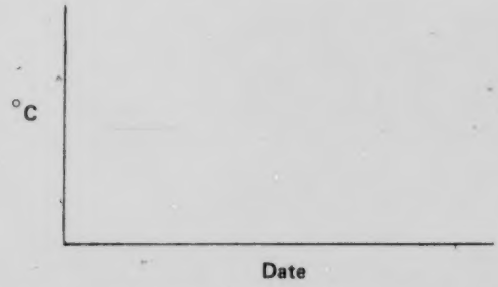
Above is an illustration of a Celsius thermometer. If we examine the illustration we can see that water boils at 100°C, normal body temperature is 37°C, room temperature is 20° or 21°C, and water freezes at 0°C.

Notice that any temperature that is below freezing is shown by a negative number. Also we know that outdoor temperatures, even in hot weather, are below body temperature.

Questions:

1. Record the classroom temperature and the outside temperature over as long a period of time as possible. Check them at the same time each day.

2. Make a graph showing the results obtained. Use different colors for indoor and outdoor temperatures.



3. Discuss the probable range of outside temperatures in your area over a one-year period.

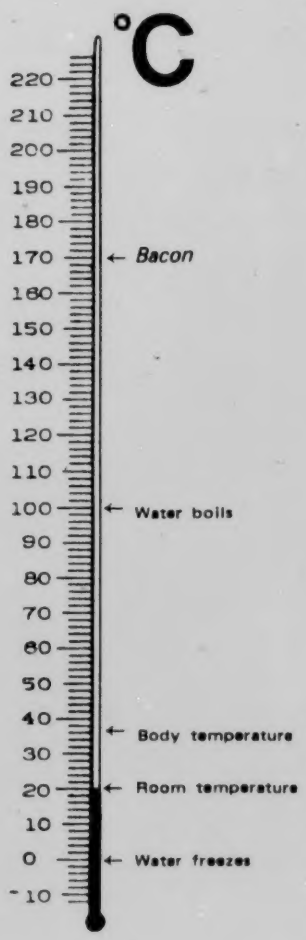
4. Fill in and memorize the following:

Water boils	_____	°C
Body temperature	_____	°C
Room temperature	_____	°C
Water freezes	_____	°C

5. The following table was found on the handle of an electric frying pan.

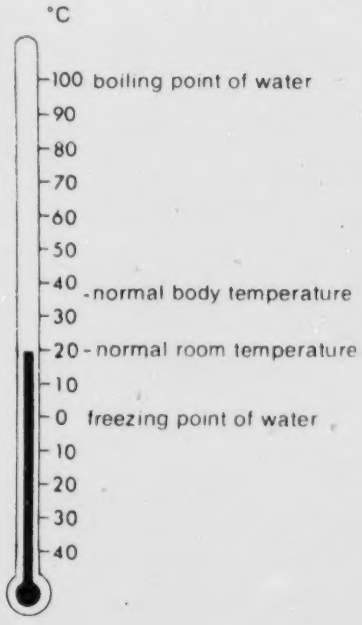
Item	°C
a. Bacon	170
b. Cake	150
c. Chili	110
d. Chops	180
e. Eggs	150
f. Fish	195
g. Fries	160
h. Ham	170
i. Liver	180
j. Steak	215

Locate each of the temperatures on the thermometer shown at the right.



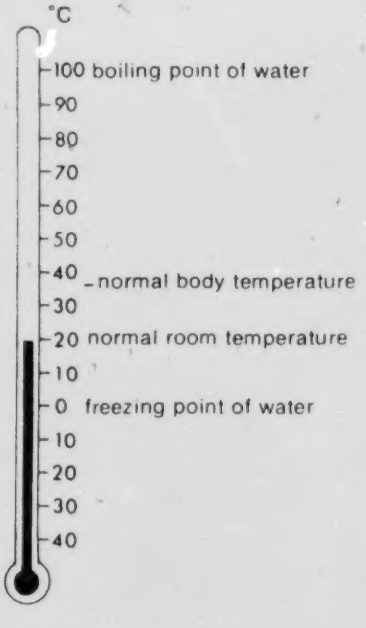
6. A table on a 4-litre container of anti-freeze is shown below. Locate each of these temperatures on the thermometer illustration given.

Cooling System Capacity (litres)	Temperature protected to if you add 4 litres of antifreeze (°C)
8	-37
9	-29
10	-24
11	-21
12	-18
13	-16
14	-14
15	-13
16	-12



7. An automobile mechanic stated that a rule of thumb for testing automobile air conditioners is that the air coming out of the vents should be 22°C less than the outside temperature. Using this rule, complete the following table.

Outside Temperature °C	Temperature of air coming out A/C vents °C
38°	
35°	
32°	
29°	
25°	



8. Locate each of the *outside* temperatures of problem #7 on the thermometer illustrated .

9. Suppose that the figure shown represents a house thermostat which regulates the heating system. How do you think it would feel in the house if it were:

a. 10°C inside?

b. 21°C inside?

c. 33°C inside?

Explain your statements.

Multiple choice – Choose the most logical answer. Be prepared to defend your choice.

10. We would probably say that there is a heat wave if the outside temperature is _____.

a) 10°C b) 21°C c) 35°C d) 95°C

11. The lake froze over last night. It went down to _____ .

a) -15°C b) -3°C c) 2°C d) 15°C

12. The President asked the people to place their thermostats at _____ in order to conserve energy.

a) 10°C b) 19°C c) 30°C d) 68°C

13. The boy had a slight fever. His temperature was _____ .

a) 38°C b) 80°C c) 98°C d) 101°C

14. Let's go to the beach! It must be at least _____ outside.

a) 15°C b) 30°C c) 50°C d) 90°C

15. I had better wear a sweater; it's _____ outside.

a) -2°C b) 0°C c) 15°C d) 24°C

16. I'm glad I wore my coat; it must be about _____.

a) 8°C b) 20°C c) 35°C d) 45°C

17. The normal operating temperature for the engine in this car is _____ .

a) 82°C b) 100°C c) 180°C d) 220°C

18. The directions say to place this T.V. dinner in an oven preheated to _____ .

a) 25°C b) 37°C c) 100°C d) 220°C

19. The water in the hot-water heater in my home is _____.

a) 37°C b) 60°C c) 100°C d) 140°C

20. The directions say to bake this cake at _____ .

a) 21°C b) 80°C c) 190°C d) 400°C

21. Tell which of the following represents a colder temperature. *Do not convert,* but reason the answers from the temperatures you have memorized.

a) 10°F or 20°C
b) 0°F or 0°C
c) 100°F or 80°C
d) 210°F or 100°C
e) 98.6°F or 40°C

22. If there are some temperatures in Fahrenheit that you wish to know in Celsius and you do not have a conversion chart, you may use the mathematical formula,

$$°C = \frac{°F - 32}{1.8}$$

UNIT IV – LINEAR MEASURE

Lesson 1 — **Units of Length**

Objectives:

1. You should be able to write, from memory, the common units of length in the SI metric system.

2. You should be able to state the SI base unit for length.

3. You should be able to state the relationship of each unit to the base.

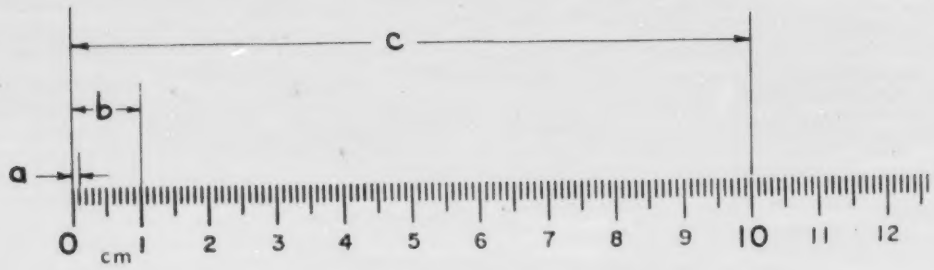
4. You should be able to write the symbol for each unit.

The SI base unit of length is the **metre**. The word "metre" comes from the Greek word "metron," which means a measure. Originally the metre was defined as one ten-millionth of the distance from the North Pole to the equator along the meridian of the earth running near Dunkirk in France and Barcelona in Spain. An international prototype of platinum-iridium was constructed to equal this distance. The 11th CGPM in 1960 changed the definition of metre to a length equaling 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels of $2p_{10}$ and $5d_5$ of the krypton-86 atom.

To form other units of length, the prefixes mentioned in Chapter II are used. The commonly used units are shown in the chart below.

Common Metric Units of Length

Unit	Relationship to Base	Symbol
kilometre	1000 metres	km
metre		m
decimetre	1/10 or 0.1 metre	dm
centimetre	1/100 or 0.01 metre	cm
millimetre	1/1000 or 0.001 metre	mm



The distance "a" is the actual length of one millimetre or .001 m. The distance "b" is the actual length of one centimetre or .01 m. The distance "c" is the actual length of one decimetre or .1 m.

Questions:

1. What is the SI base unit for length?
2. What are 5 common units of length? Be sure to memorize these.
3. How many metres are in one kilometre?
4. How many decimetres are in one metre?
5. How many centimetres are in one metre?
6. How many millimetres are in one metre?
7. How many metres are in one decimetre?
8. How many metres are in one centimetre?
9. How many metres are in one millimetre?
10. From memory write the symbols for kilometre, metre, decimetre, centimetre, and millimetre.

UNIT IV – LINEAR MEASURE

Lesson 2 **Conversion Within SI Units of Length**

Objectives:

1. You should be able to change from one SI unit of length to another SI unit of length by performing an appropriate multiplication or division.

2. You should be able to write mixed units as a single unit.

In Chapter I (page 10), we changed 13¾ feet to inches. We changed 1205 feet to miles. These are examples of conversion between units of length in the customary system. At that time we also showed an example of changing metres to centimetres and kilometres. This is the type of problem we will consider in this lesson.

Before continuing, you should review chapter I, lesson 4, Multiplication and Division by Powers of 10 and chapter II, lesson 1, The Prefixes.

In chapter I, lesson 3 we stated that:

$$13.75 \text{ metres} = 1375 \text{ centimetres}$$

and

$$1205 \text{ metres} = 1.205 \text{ kilometres}$$

In order to change from metres to centimetres, we must have memorized the fact that *centi* means 1/100, and therefore there are 100 centimetres in each metre. If we have 13.75 metres, then we *multiply* the number of metres by 100 to obtain the equivalent number of centimetres.

$$(13.75 \text{ m})\left(100\frac{\text{cm}}{\text{m}}\right) = 1375. \text{ centimetres}$$

In order to change from metres to kilometres, we must have memorized that *kilo* means 1000 times, and therefore one kilometre equals 1000 metres. Consequently we must *divide* the number of metres by 1000 to obtain the equivalent number of kilometres.

$$\frac{1205 \text{ metres}}{1000\ \frac{\text{m}}{\text{km}}} = 1.205 \text{ kilometres}$$

Using common sense, we can reason that if it takes 1000 metres to make one kilometre, and we started with 1205 metres, then we had to wind up with a little over 1 kilometre.

Multiplying and dividing by powers of 10 is in itself very simple. The only problem is: do we multiply or do we divide? That too becomes simple once we realize that, when we change from a larger unit to a smaller unit, we must end up with *more* of the smaller unit – more centimetres than metres, for example. Therefore we *multiply* the number of metres (by 100) to get *more* centimetres. Similarly, to change to a larger unit we must end up with *fewer* of the larger unit, and so we *divide*. In the above case we divided the number of metres by 1000 and got kilometres.

The following two rules summarize what we have said and should help simplify conversions.

1. When changing from a *larger* unit to a *smaller* unit, always *multiply* (move the decimal point to the right). (That way we get *more* of the smaller unit than we had of the larger unit.)

2. When changing from a *smaller* unit to a *larger* unit, always *divide* (move the decimal point to the left). (That way we get *fewer* of the larger unit than we had of the smaller unit.)

Examples:

1. Change 725 millimetres to metres.

   a. The first decision is that we must *divide* (move the decimal point to the left) because we are changing from a smaller to a larger unit.

   b. The second decision is that we must divide *by 1000* (move the decimal point *3* places to the left). (Remember that there are 1000 millimetres in one metre.)

   c. 725 millimetres = 0.725 metres

2. Change 6 kilometres to metres.

   a. The first decision is that we must *multiply* (move the decimal point to the right) because we are changing from a larger to a smaller unit.

   b. The second decision is that we must multiply *by 1000* (move the decimal point *3* places to the right). (Remember that each kilometre is equal to 1000 metres.)

   c. 6 kilometres = 6000 metres

3. Change 5000 centimetres to metres.

   a. The first decision is that we must *divide* (move the decimal point to the left) because we are changing from a smaller to a larger unit.

   b. The second decision is that we must divide *by 100* (move the decimal point *2* places to the left). (Remember that 100 centimetres equal 1 metre.

   c. 5000 centimetres = 50 metres

When we are writing linear measurements we never use mixed units. Therefore, we will never record a measurement as, say, 5 metres 3 centimetres. Instead this will be written as 5.03 metres or 503 centimetres – whichever unit we wish to use.

Example:

In measuring an opening for a picture window, the initial reading was 2 metres 2 centimetres 5 millimetres. Give this measurement in millimetres.

Solution:

2 metres	=	2000 millimetres
2 centimetres	=	20 millimetres
		5 millimetres
		2025 millimetres

Problems:

1. Convert the following measurements as indicated.

A.	3.76 metres to centimetres	_____	cm
B.	6675 centimetres to metres	_____	m
C.	1650 centimetres to metres	_____	m
D.	52 495 metres to kilometres	_____	km
E.	642 centimetres to metres	_____	m
F.	13 569 millimetres to metres	_____	m
G.	0.576 kilometres to metres	_____	m
H.	3.29 metres to centimetres	_____	cm
I.	0.097 metres to millimetres	_____	mm
J.	42 190 millimetres to metres	_____	m

2. Convert the following measurements.

A. 8.7 metres to centimetres _____ cm

B. 352 millimetres to centimetres _____ cm

C. 0.721 metres to millimetres _____ mm

D. 0.01 metres to millimetres _____ mm

E. 96 metres to kilometres _____ km

F. 4020 centimetres to metres _____ m

G. 20 metres to centimetres _____ cm

H. 4000 metres to kilometres _____ km

I. 6 centimetres to metres _____ m

J. 0.06 centimetres to millimetres _____ mm

3. Convert the following measurements.

A. 0.00213 kilometres to metres _____ m

B. 5321 decimetres to kilometres _____ km

C. 11 253 millimetres to metres _____ m

D. 0.4037 metres to millimetres _____ mm

E. 93 millimetres to centimetres _____ cm

F. 973 219 metres to kilometres _____ km

G. 15 centimetres to millimetres _____ mm

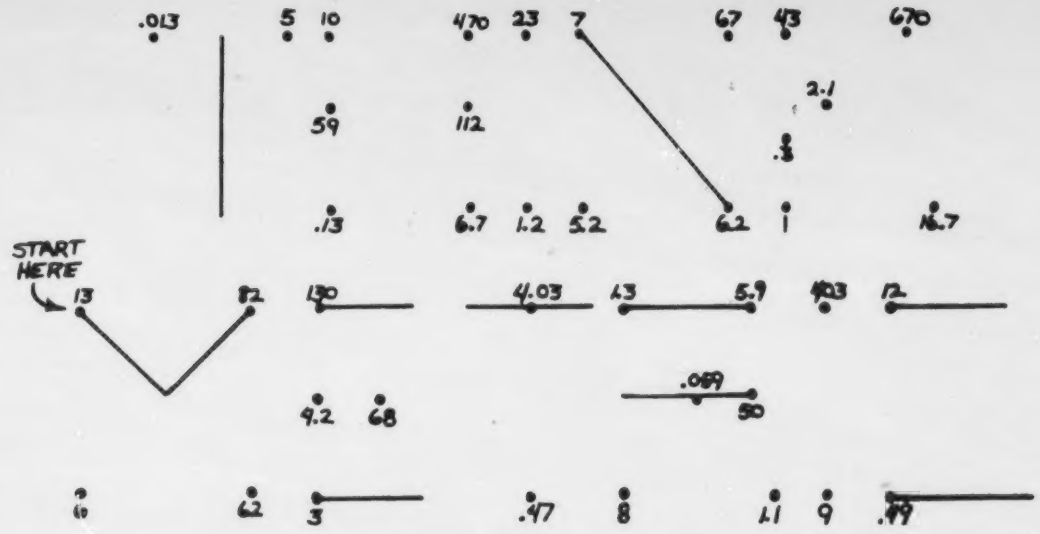
H. 0.0256 centimetres to decimetres _____ dm

I. 49.73 millimetres to decimetres _____ dm

J. 0.5 metres to centimetres _____ cm

4. BRAIN TEASER

Connect the answer to problem (a) to the answer to problem (b) for each of the 20 double problems below. Use the margins for figuring. *Watch out for changes in units!*



	(a)			(b)	
1.	8 m + 5 m = _____	m	&	9 m – 3 m = _____	m
2.	8 m + 5 m = _____	km	&	17 cm – 12 cm = _____	cm
3.	8 cm + 5 cm = _____	m	&	43 km – 33 km = _____	km
4.	8 cm + 5 cm = _____	mm	&	7 mm – 4 mm = _____	mm
5.	436 m + 764 m = _____	km	&	32 cm – 9 cm = _____	cm
6.	8 cm + 2 mm = _____	mm	&	9 cm – 28 mm = _____	mm
7.	6 cm + 7 mm = _____	mm	&	9 cm – 28 mm = _____	cm
8.	6 cm + 7 mm = _____	cm	&	1 km – 530 m = _____	m
9.	4 m + 3 cm = _____	m	&	1 km – 530 m = _____	km
10.	4 m + 3 cm = _____	cm	&	9.8 m – 0.8 m = _____	m
11.	5 cm + 20 mm = _____	cm	&	9 m – 380 cm = _____	m
12.	4 cm + 3 mm = _____	mm	&	0.7 m – 69 cm = _____	cm
13.	9 mm + 4 mm = _____	cm	&	27 cm – 19 cm = _____	cm
14.	10 m + 200 cm = _____	m	&	52 cm – 3 cm = _____	m
15.	365 cm + 225 cm = _____	m	&	8 cm – 3 cm = _____	mm
16.	5 cm + 9 mm = _____	mm	&	14 cm – 28 mm = _____	mm
17.	356 mm + 324 mm = _____	cm	&	7 cm – 28 mm = _____	cm
18.	49 cm + 18 cm = _____	mm	&	11 mm – 8 mm = _____	cm
19.	38 m + 21 m = _____	km	&	3.9 mm – 2.8 mm = _____	mm
20.	8 mm + 13 mm = _____	cm	&	18 m – 1.3 m = _____	m

5. MIX AND MATCH PUZZLE I
(Linear Measure)

On the next page you will see the sheet you are going to work on.

Cut the squares on this page apart. You are going to arrange these squares on the next page so that every measurement *has the same value* as the measurement adjacent (right next) to it. See the example below. When you are sure your solution to the puzzle is correct, paste or tape your squares down.

57 km 0.01 m 4 m 0.23 km	23 mm 4 mm 400 m 5.7 km	0.057 km 1000 cm 40 mm 230 dm	570 mm 10 cm 0.4 mm 230 mm
5.7 m 0.01 m 0.4 cm 57 mm	0.023 hm 400 cm 0.1 cm 5.7 mm	230 cm 1 m 400 mm 23 cm	23 m 4 cm 10 dm 57 cm
230 m 400 km 4000 m 57 dm	5700 m 0.04 m 10 dm 0.057 cm	2.3 dm 1 mm 4 mm 57 m	23 cm 0.4 m .04 mm 570 km
5.7 cm 0.1 mm 40 mm 230 km	0.57 cm 4 km 10 m 2.3 cm	23 m 0.4 km 1 dm 2300 mm	0.057 mm 0.4 cm 0.01 mm 0.023 km

Example:

0.4 cm	4 mm 400 m 5.7 km	0.4 km
	5700 m	

SOLUTION to MIX and MATCH PUZZLE I

57 km 0.01 m 4 m 0.23 km			

Express each of the following in a single unit.

Example: 2 m 3 cm in metres

$$\begin{array}{rr} & 2 \text{ m} \\ 3 \text{ cm} = & 0.03 \text{ m} \\ \hline & 2.03 \text{ m} \end{array}$$

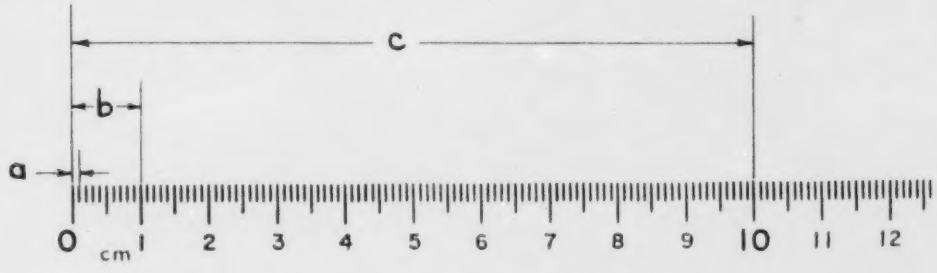
6. 3 m 25 mm in metres _____
7. 7 cm 4 mm in millimetres _____
8. 3 m 12 mm in metres _____
9. 5 cm 2 mm in millimetres _____
10. 14 km 252.2 m in kilometres _____
11. 21 dm 5 cm in centimetres _____
12. 10 m 2 dm in metres _____
13. 17 km 302 m in kilometres _____
14. 10 m 4 cm 2 mm in metres _____
15. 2 km 3 m 47 cm in metres _____

UNIT IV – LINEAR MEASURE

Lesson 3 — **Measuring and Estimating in Units of Length**

Objectives:

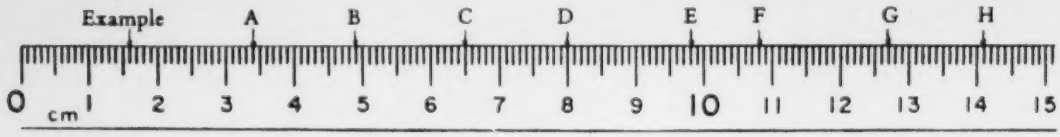
1. You should be able to read a metric ruler.
2. You should be able to use a metric ruler to measure distances.
3. You should be able to give your answer in any SI unit of length.



The smallest marking on many common metric rulers is the millimetre. The distance "a" above is the actual length of one millimetre or .001 metre. The distance "b" is the actual length of one centimetre. Ten centimetres equal one decimetre. Decimetres may or may not be specially marked on your ruler, metre stick, or tape measure. Notice that in the illustration there were no special marks for the decimetre. The distance "c" is the actual length of one decimetre.

Problems:

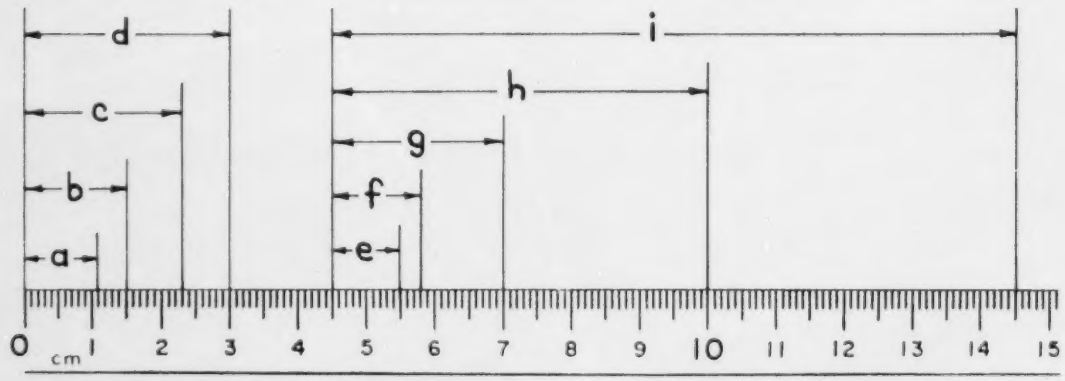
1. Write in the number of centimetres and millimetres for points A through H as shown on this metric ruler. Then express each one in centimetres, using a decimal.



Example: 1 cm 6 mm or 1.6 cm

A. _____ cm ___ mm or ____ cm
B. _____ or _____
C. _____ or _____
D. _____ or _____
E. _____ or _____
F. _____ or _____
G. _____ or _____
H. _____ or _____

2. On the chart below, write the number of millimetres and centimetres for each of the following distances:



Millimetres				Centimetres			
a.	11	f.	_____	a.	1.1	f.	_____
b.	_____	g.	_____	b.	_____	g.	_____
c.	_____	h.	_____	c.	_____	h.	_____
d.	_____	i.	_____	d.	_____	i.	_____
e.	_____			e.	_____		

3. Make your own tape measure. Mark off about 110 centimetres.

4. In teams of two, measure the following with the metric tape measure or an appropriate measuring device. Record *your own* measurements, as found by your teammate, to the nearest whole centimetre.

   a. waist _____

   b. hips _____

   c. chest or bust _____

   d. arm length _____

   e. height _____

5. Measure the following with the metre stick to the nearest whole centimetre.

   a. width of the classroom _____

   b. length of the classroom _____

   c. width of teacher's desk _____

   d. length of teacher's desk _____

   e. height of the teacher's desk _____

   f. width of the doorway into the room _____

   g. height of the doorway _____

6. Using a ruler or metre stick, measure the following to the nearest millimetre.

   a. The width of this book _____

   b. The height of this book _____

   c. The thickness of this book _____

   d. The length and width of a floor tile in the classroom _____

   e. The diagonal of a floor tile _____

   f. The distance across your thumbnail _____

7. a. Estimate the length of each of the following. Write your estimate to the left of each line.

   b. Find the actual measure with a ruler. Write the measurement above each line, in front of the unit that has been designated.

mm
_____

mm
_____

cm
_____

mm
_____

mm

cm

cm

mm

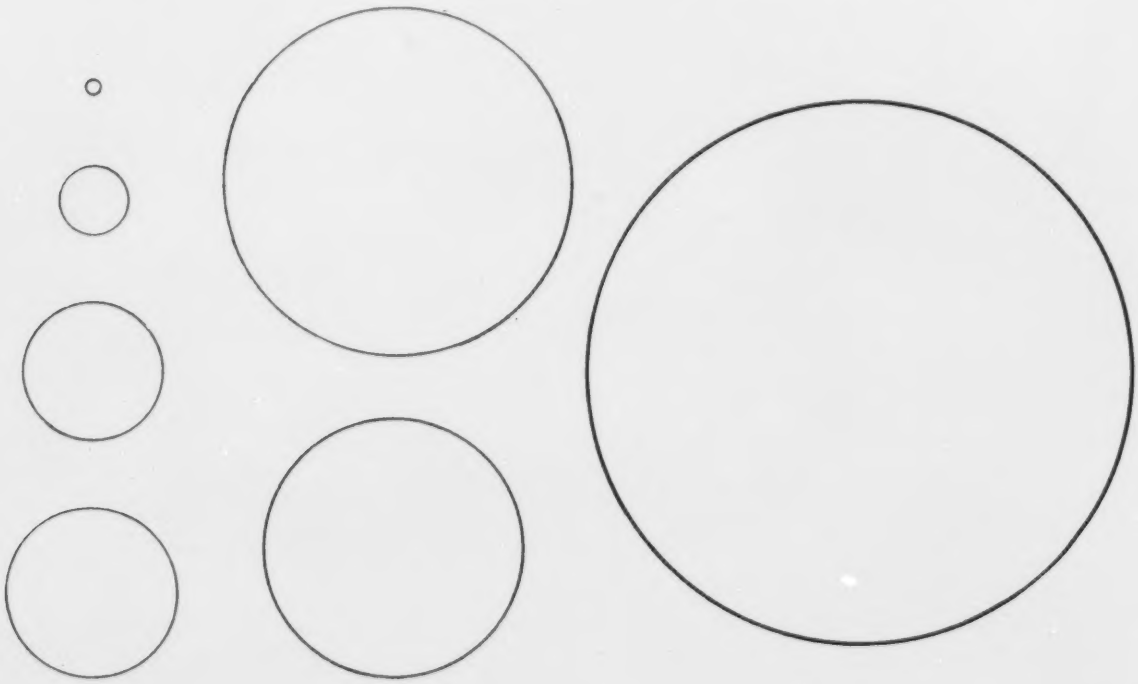
8. a. Estimate (in centimetres) the length and width of a 3-ring binder cover.

   _____ _____

   b. Find the actual measures with a ruler. _____ _____

9. a. Estimate the diameters (in centimetres) of the following circles. Write your estimate near each circle.

   b. Find the actual measure with a ruler. Write the measurement within each circle.



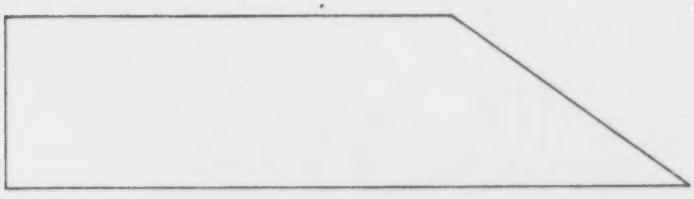
   c. Convert all the measurements to millimetres.

10. From memory, draw the length of a millimetre, a centimetre, a decimetre. DO NOT use any type of measuring device. Check to see how close you have come after you have finished.

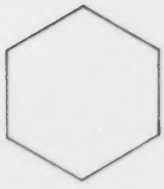
The perimeter is the distance around the outside of an object. Measure the lengths of the sides of each of the following figures and then give the perimeter of each.

11.

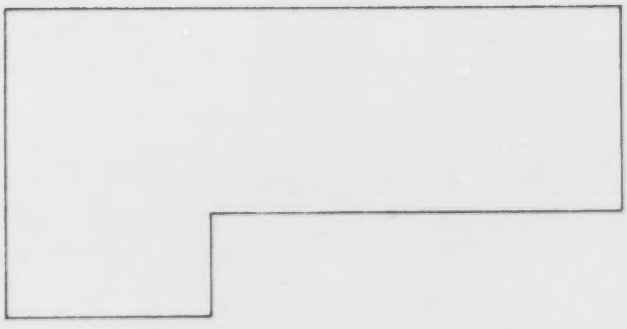
12.



13.



14.

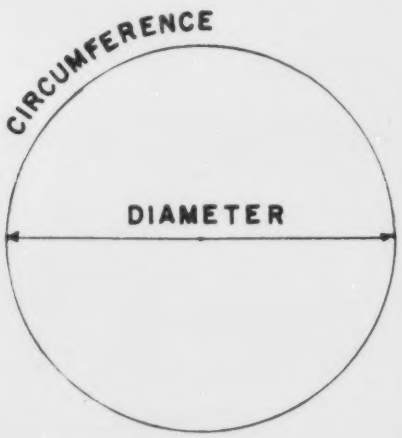


Lesson 4 — **Diameter, Radius, Circumference**

Objective: You should be able to compute the circumference of a circle when given either the diameter or the radius.

The distance across a circle through its center is called the *diameter* of the circle.

The perimeter of a circle has a special name. It is called the *circumference.* Measure any circle – a tire, a grinding wheel, a dish, a circular path – and you will find that *the circumference is always a little over 3 times the diameter of the circle.*



A more exact figure for this relationship is 3.1416 times the diameter. Depending on how accurate we need to be in finding a circumference, we may use the figure of 3.14 or 3.1416.

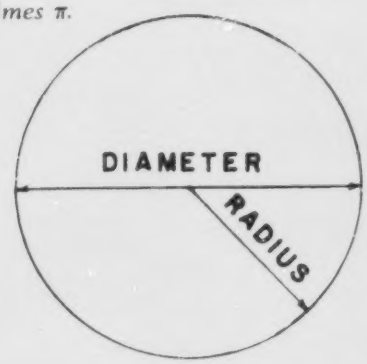
Scientists sometimes use even a more accurate figure. This number, 3.1416, has been given a name, the Greek letter π or pi. We write the above relationship in a sort of shorthand, called a formula. It is

$$C = \pi D$$

This stands for : Circumference equals π times the diameter.

With other members of your class, measure the diameters and circumferences of at least five circles, as accurately as you can. Some suggestions of things to measure are pulleys, grinding wheels, clock faces, circular tables, and any other circular objects in your shop or lab. Divide each circumference by the diameter. The more accurate your measurements, the closer you will come to pi, or 3.1416. See how accurate you can be.

The radius of a circle is the distance from the center to the curve of the circle. Since the radius is equal to one-half the diameter, *the circumference is also 2 times the radius times* π.



We write this as a formula also.

$$C = 2\pi r$$

Do you see why this formula follows from the other one?

When doing the problems below, round off your answers to the *same number of decimal places as there are in the given measurement.* Then, if appropriate, convert the answer to the next larger decimal unit.

PROBLEMS

1. Find the circumference of the circles below when given the diameter, D. (Use π = 3.14.) For your answer, use the most appropriate decimal unit.

   A. D = 22 mm C = _____

   B. D = 25 mm C = _____

   C. D = 3.2 cm C = _____

   D. D = 1.08 cm C = _____

   E. D = 124 cm C = _____

2. Find the circumference of a circle when given the radius, r. (Use π = 3.14.) For your answer, use the most appropriate decimal unit.

   A. r = 32 mm C = _____

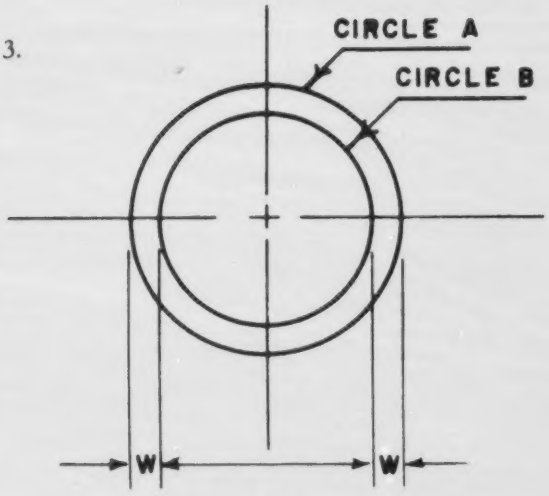
   B. r = 29.3 mm C = _____

   C. r = 40 mm C = _____

   D. r = 13.2 cm C = _____

   E. r = 9.04 cm C = _____

3.



In the pulley illustrated to the left: The radius of circle A is 48 mm, and the distance W is 6 mm. Find the radius of circle B. Then find the circumference of circle B. (Use π = 3.1416.)

r of B = _____

C of B = _____

4. If the diameter of circle B in problem 3 is 3.8 *cm* and W = 4 *mm*, find the diameter and circumference of circle A. (Use π = 3.14.)

d of A = _____

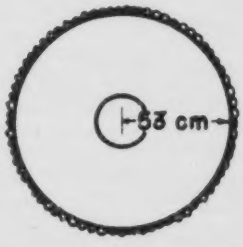
C of A = _____

5. A landscape gardener had to lay out a circular bed that was to be 7 metres across. It was to be edged with tiles. What was the distance that had to be edged? If each tile took 10 centimetres, how many tiles would be needed? (Use the less exact value of pi.)

Distance _____

No. of tiles _____

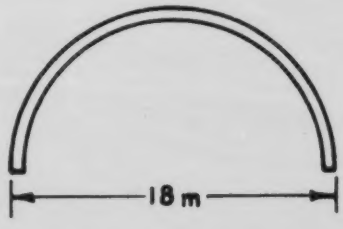
6.



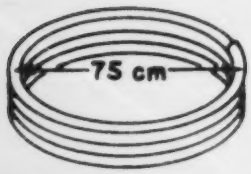
A dress designer designed a skating outfit having a perfectly circular skirt with a radius of 53 cm. About how much edging would such a skirt require?

7. A mason had to estimate the number of bricks for a semicircular wall 18 m across. What was the length of the wall? (Hint: Find the length of a full circle first. A semicircle is half a full circle.) (Which value of π would be appropriate here?)

_____



8. How many bricks were needed for a single course if each brick and its mortar took 200 mm?

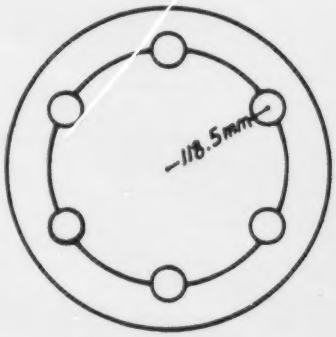
9. 

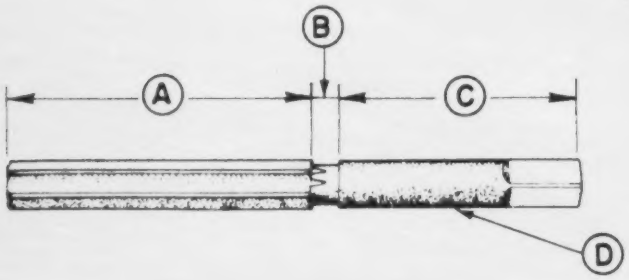
A plumber had a coil of copper tubing and needed to know how long it was. The distance across the coil was 75 cm, and there were four complete circles of tubing. About how many metres of tubing did he have?

10. A machinist had to lay out 6 holes equally spaced on a bolt circle 118.5 mm in radius. What was the circumference of the bolt circle? (Which value for π should you use?) How far apart, center-to-center, were the holes?

_____

_____

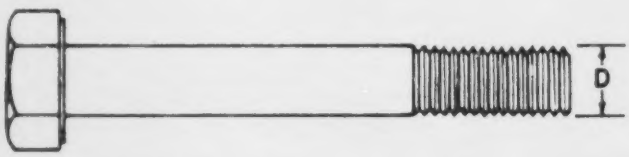




11. On the above reamer, measure the lengths of A, B, and C. What is the diameter of D? (Use the most appropriate unit.)

A. _____ B. _____ C. _____ D. _____

12. For the same reamer, compute the circumference of D, using the most exact figure you know for π.



13. What is the total length of this bolt in millimetres? _____

In centimetres? _____

14. What is the diameter (D) of the threads on the bolt in millimetres? _____

In centimetres? _____

15. What is the circumference of the unthreaded portion of the bolt? _____

For Class Discussion

1. In what trades would you be likely to use 3.1416 for π?

2. In what trades would you be likely to use 3.14 for π?

3. Would you ever be likely to use just "3 plus a little more"?

4. Give examples of diameter measurements that are extremely accurate; that are moderately accurate; that are rough approximations.

5. What happens to each of these when multiplied by 3.14 or 3.1416? Are the answers really as accurate as they seem to be?

6. If a diameter is 22.1 centimetres, multiplying by 3.14 gives 69.394 cm. According to our rule (p.49), how should the answer be given? What is the reason for this rule?

7. Discuss rounding off decimals. Have the class develop a rule that applies in all cases.

UNIT IV – LINEAR MEASURE

Lesson 5 — Metric Micrometer

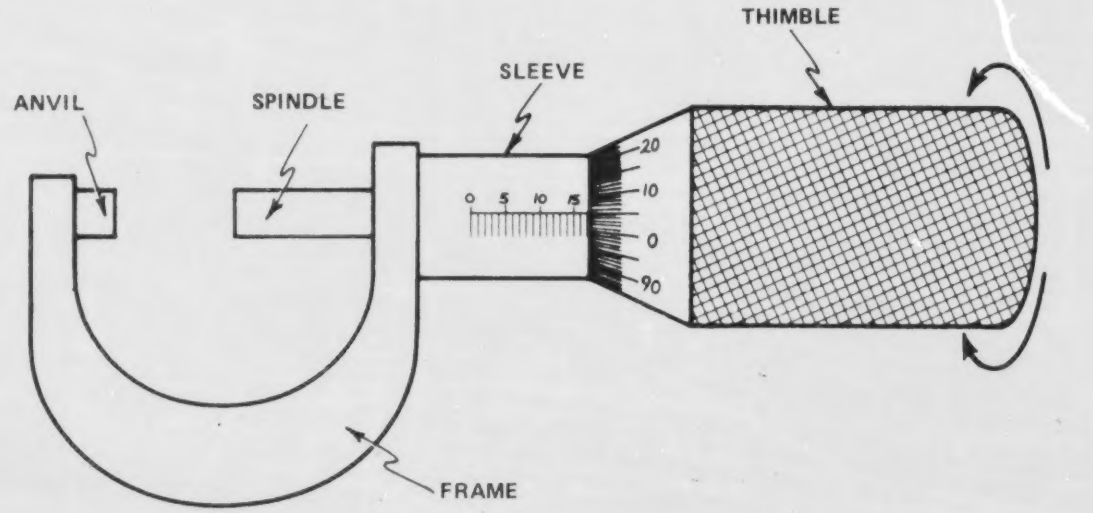
Objectives:

1. You should be able to identify the five basic parts of a metric micrometer.
2. You should be able to read the metric micrometer.
3. You should be able to use a metric micrometer to measure small distances.

The five basic parts of a micrometer are the frame, the anvil, the sleeve, the spindle, and the thimble. The spindle and the thimble are the parts that move.

When using the micrometer, the object is placed between the anvil and the spindle. The anvil is stationary, while the spindle moves toward or away from the anvil according to the direction that you turn the thimble.

The Metric Micrometer

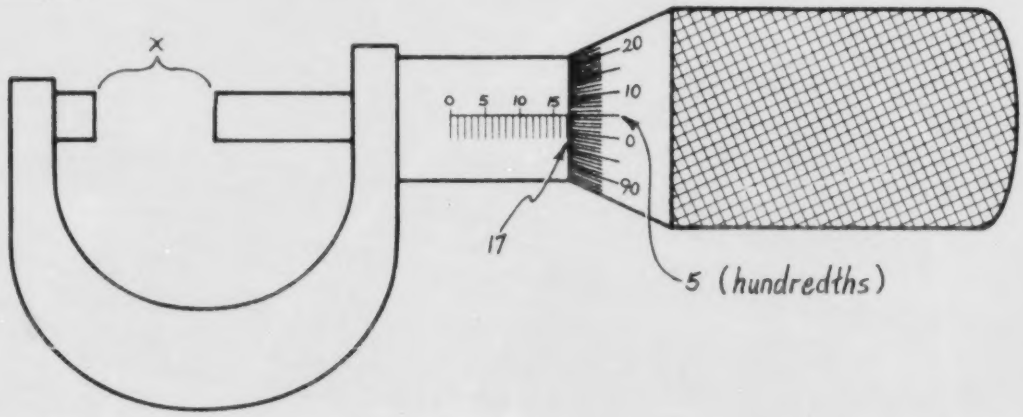


On the sleeve we find marks that indicate the number of whole millimetres. On the thimble we find 100 equally spaced marks. When the thimble is turned through one complete revolution, it will have moved one millimetre forward or back. Therefore, the marks on the thimble indicate hundredths of a millimetre. (Some thimbles have only 50 marks on the thimble and must be rotated twice to move one millimetre.)

To measure an object, place it against the anvil and rotate the thimble until the object is clamped *lightly* between anvil and spindle.

To read the metric micrometer, first count the number of whole millimeters that have been exposed on the sleeve and then add to this the number of hundreths of a millimetre as indicated by the thimble line closest to the horizontal line on the sleeve.

Example:



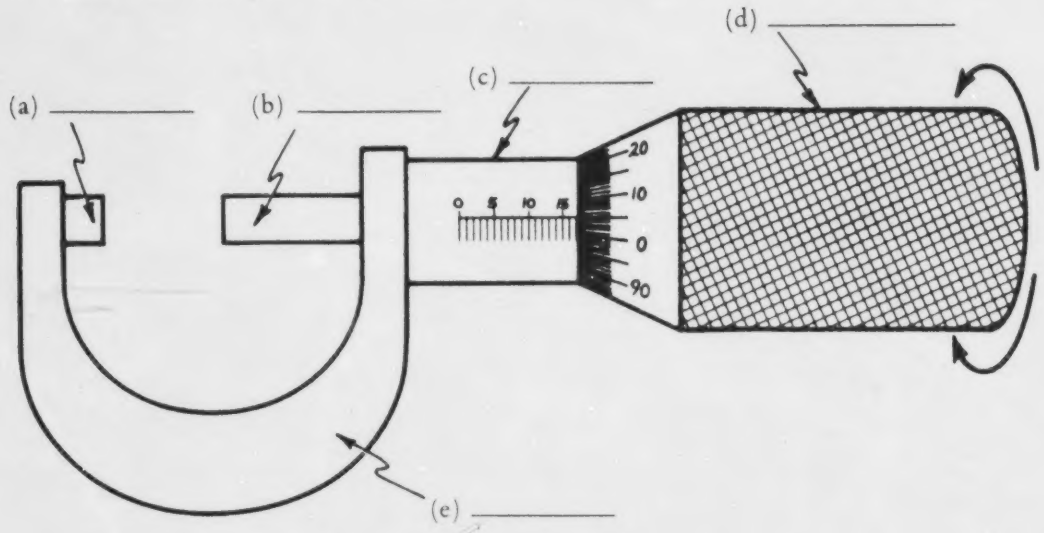
To read the measure of "X"

a.	Number of whole millimetres, as read on the sleeve	17.00 mm
b.	Hundredths of a millimetre, as read on the thimble	.05 mm
		17.05 mm

Therefore, X = 17.05 mm

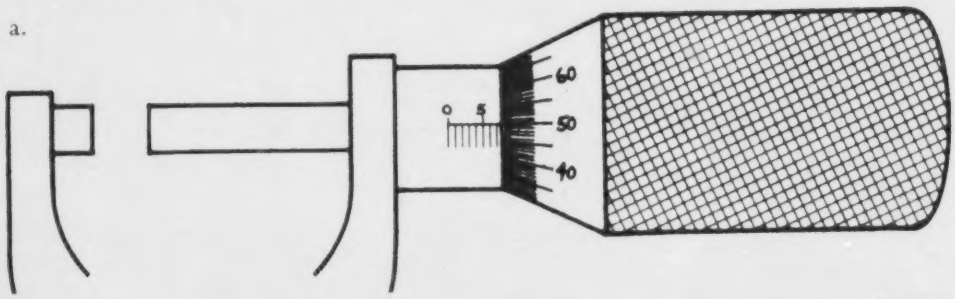
Questions:

1. Label the five parts of the micrometer.



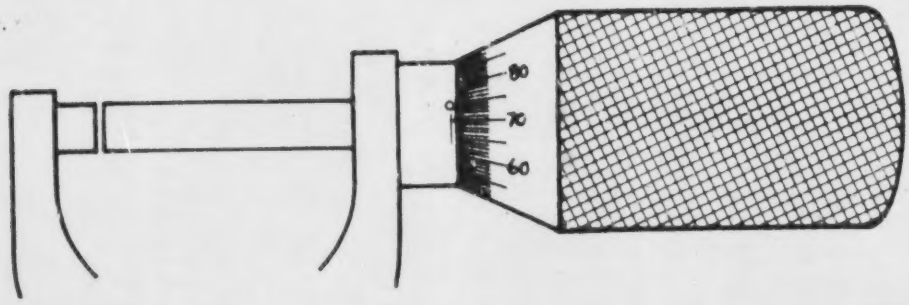
2. Read each of the following metric micrometers.

a.



_____

b.



_____

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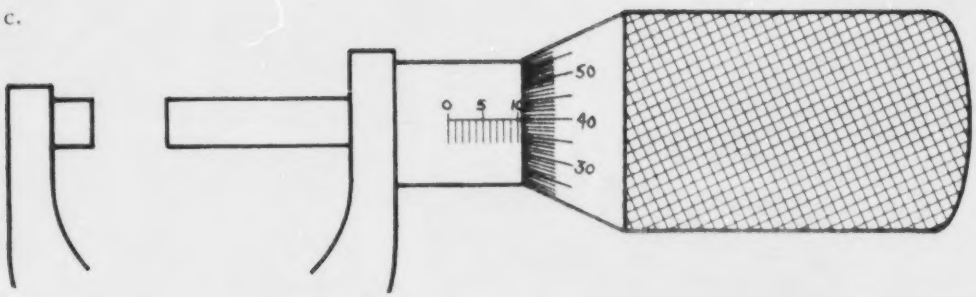
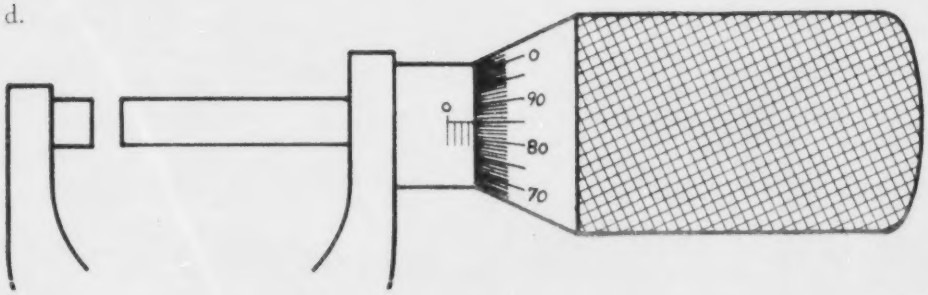
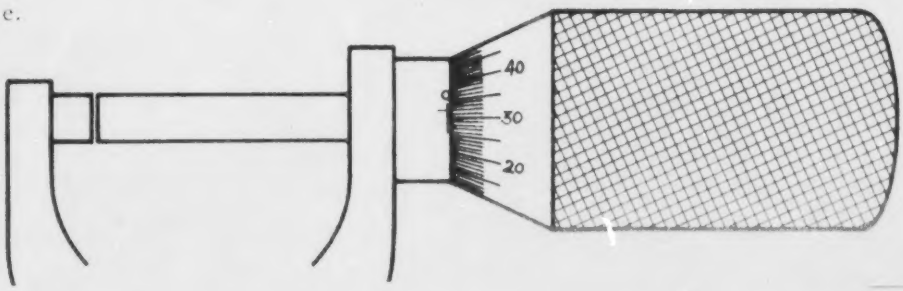
c.



d.



e.



3. Use a metric micrometer to measure the thickness of several items.

UNIT IV – LINEAR MEASURE

Lesson 6 **Metric Vernier Caliper**

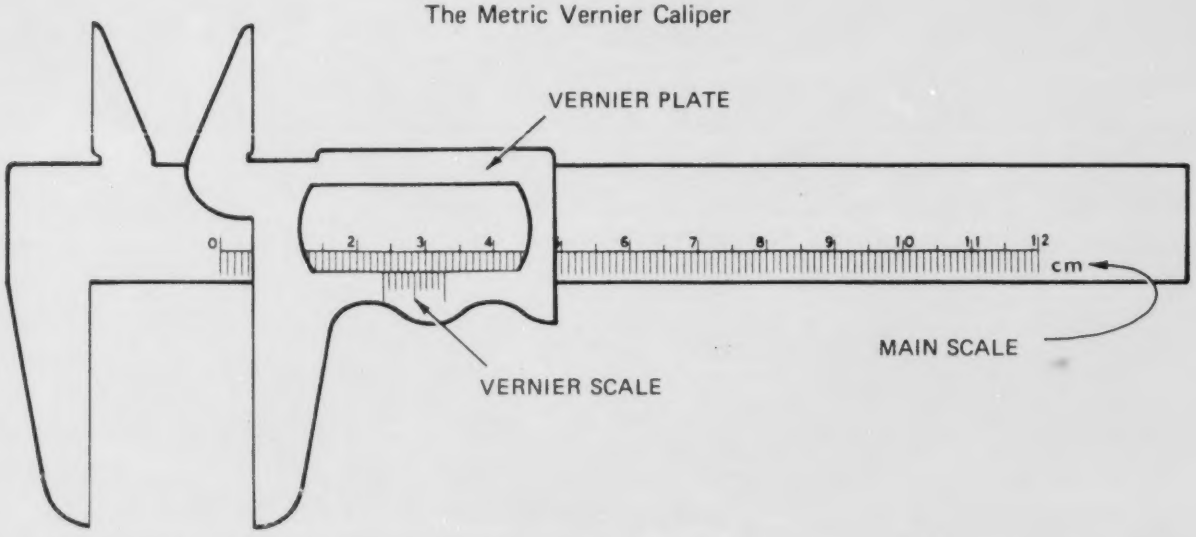
Objectives:

1. You should be able to identify the main scale and the vernier plate on a vernier caliper.

2. You should be able to read a vernier caliper

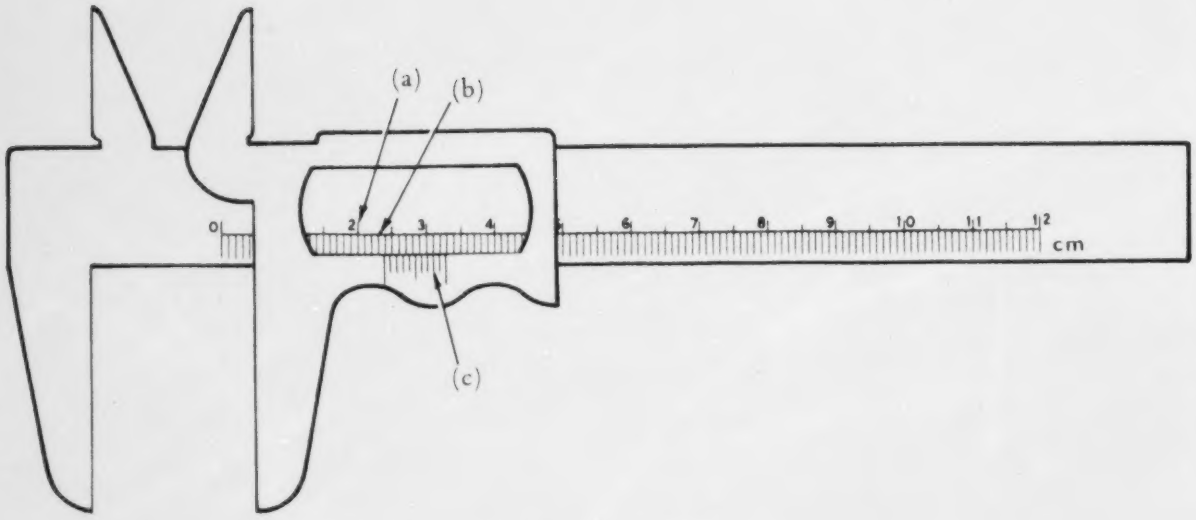
3. You should be able to use a vernier caliper to measure small distances.

The Metric Vernier Caliper



The main scale on the Vernier Caliper shown is marked from 0 to 12 centimetres. On the vernier scale we find ten equally spaced marks. They appear to be marked in millimetres, but they are not. Ten marks on the vernier scale occupy the same amount of space as 9 millimetres on the main scale.

To read the measurement of an object between the jaws of the vernier caliper, first record the number of whole centimetres and then whole millimetres that are seen on the main scale *before* the first mark on the vernier scale. To obtain the next numeral of the reading, examine the 10 marks on the vernier scale and the marks directly opposite them on the main scale. The number of the mark on the *vernier scale* that *lines up exactly* with one of the marks on the main scale is the correct tenth of a millimetre.



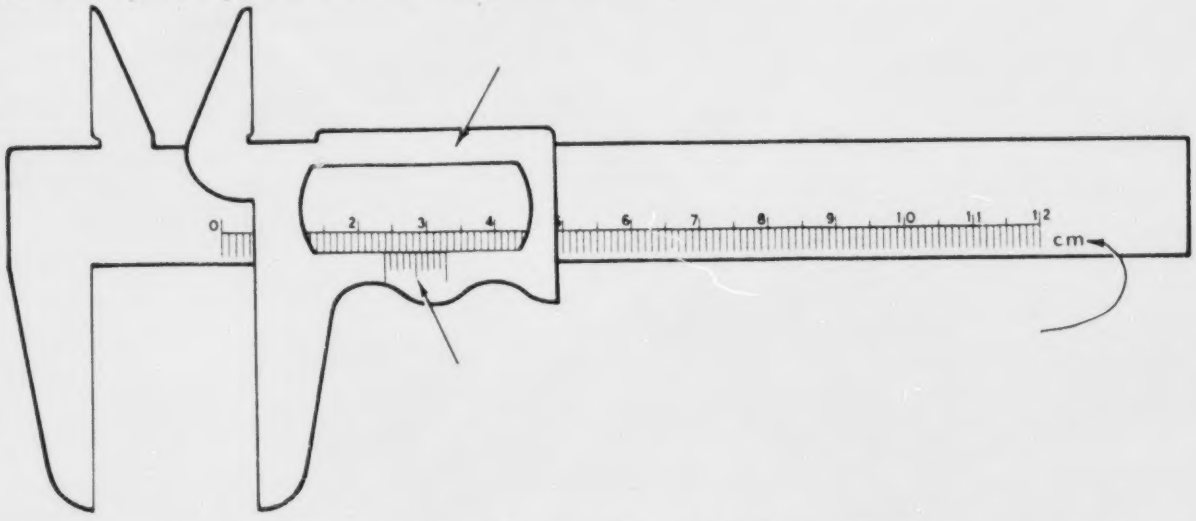
To read the vernier setting above in millimetres:

(a) Whole centimetres	2 = 20.0 mm
(b) Whole millimetres beyond the centimetre mark	3.0 mm
(c) The vernier line that lines up exactly with the main scale	.8 mm
	23.8 mm

If we wanted the above reading in centimetres, we would simply move the decimal point one place to the left for each of the three parts of the measurement. The reading would be 2.38 cm.

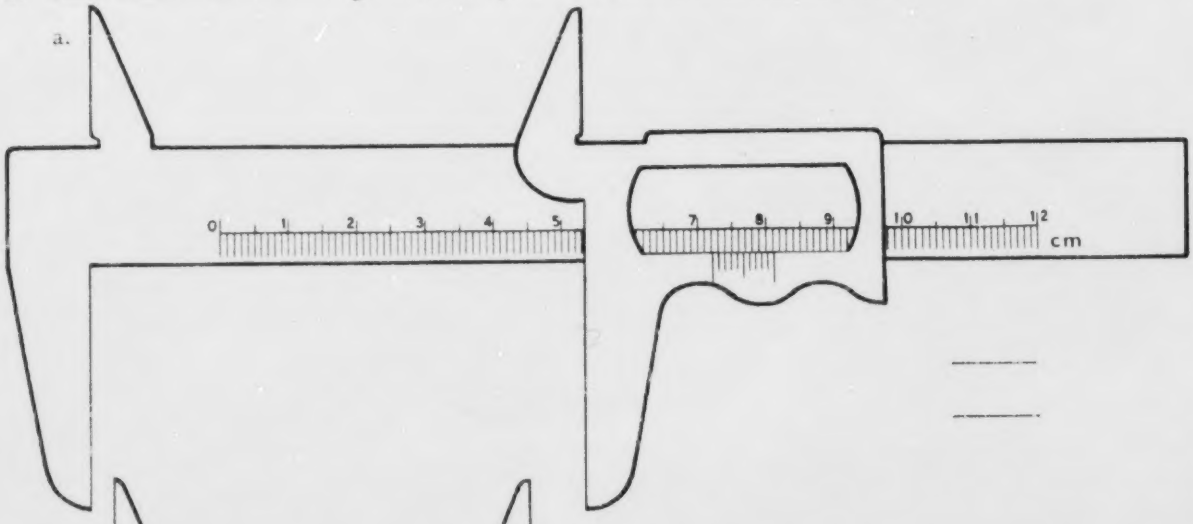
Questions:

1. Identify the 3 parts of the vernier caliper as indicated.



2. Read each of the following vernier calipers in millimetres and in centimetres:

a.



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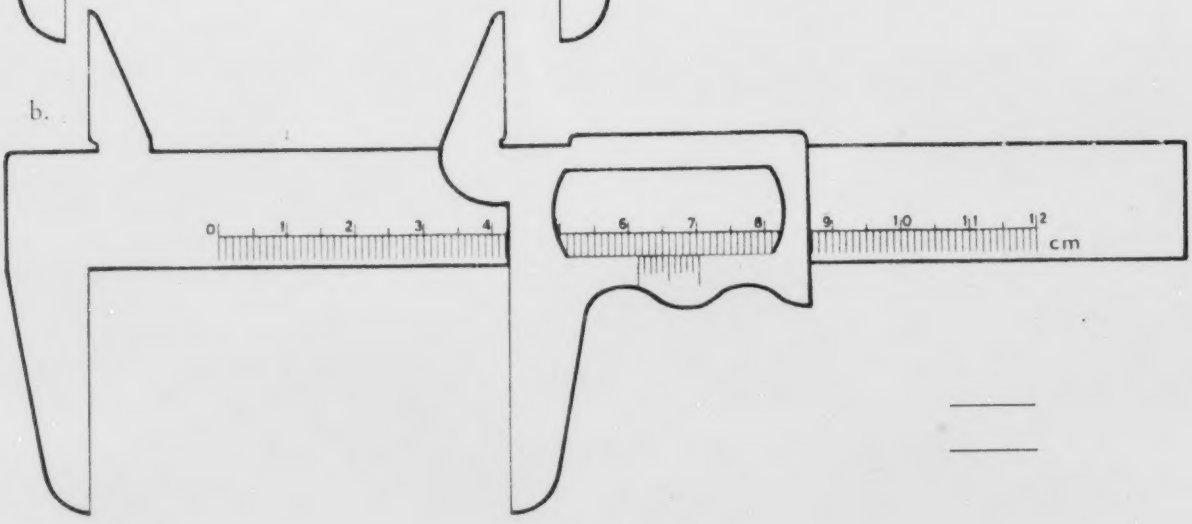
b.



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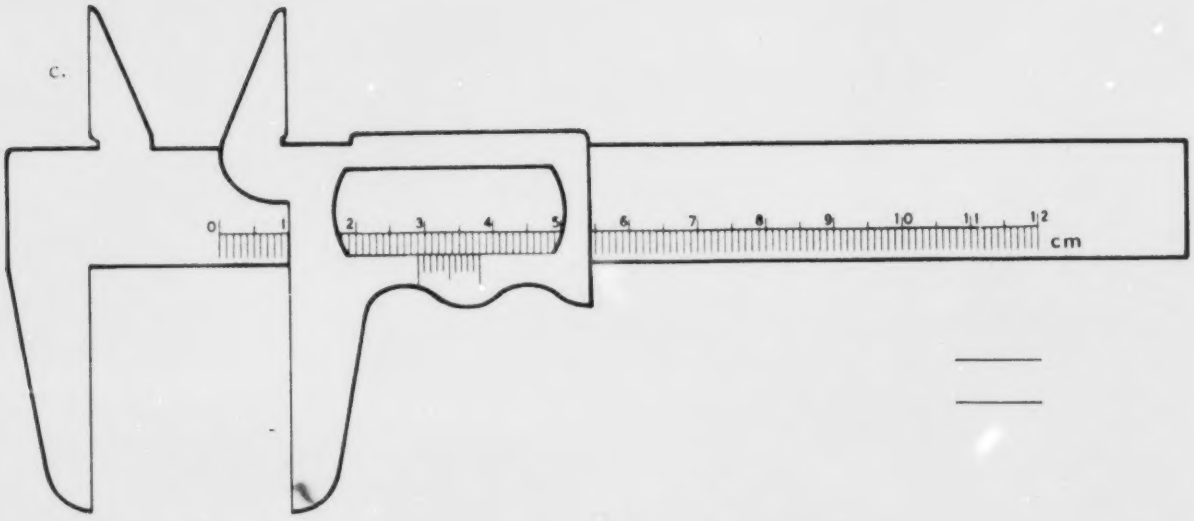
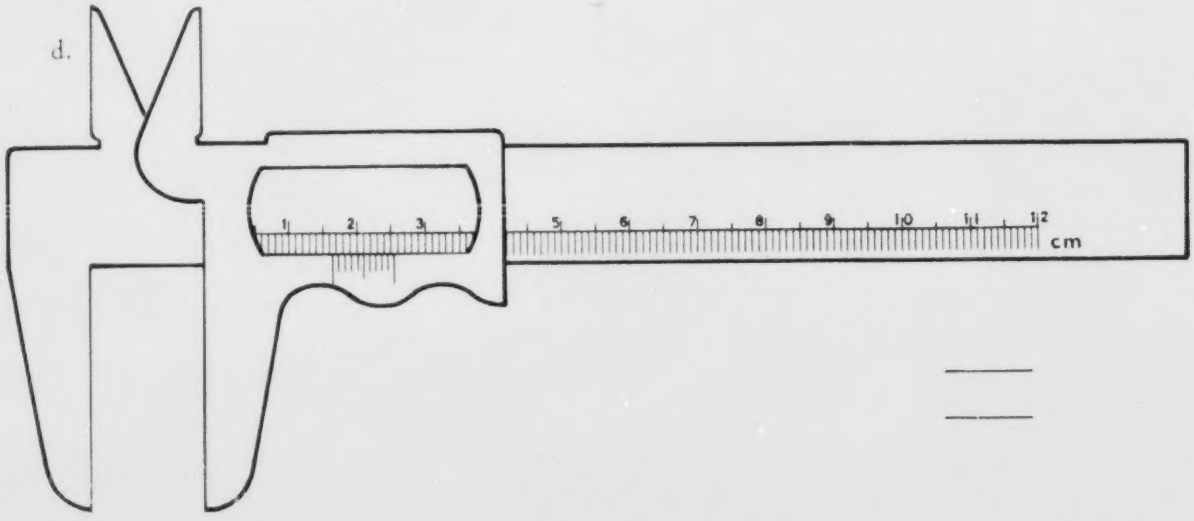
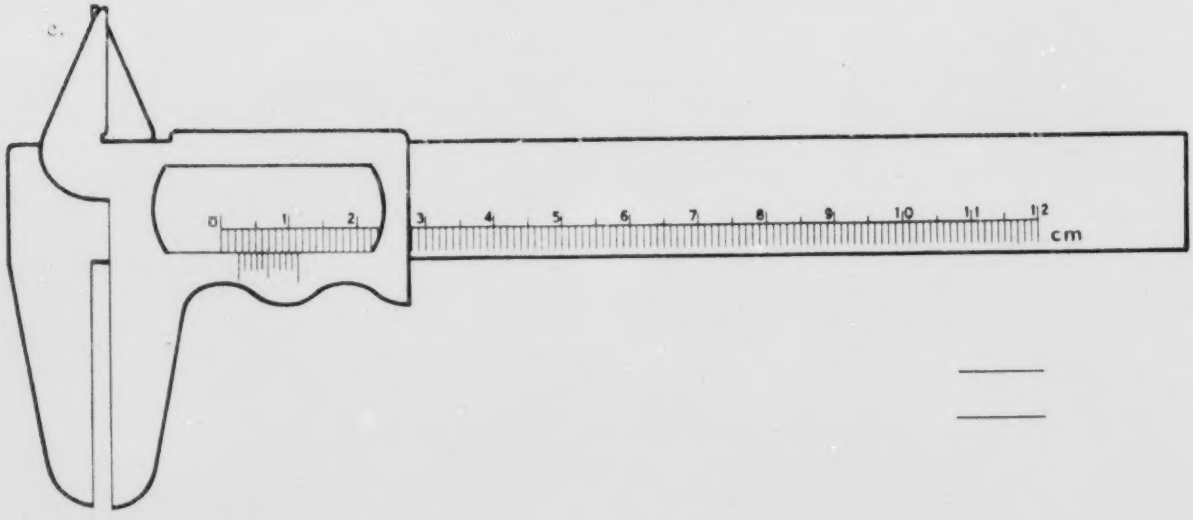
c.



d.



e.



3. Use a metric vernier caliper to measure the thickness of several items.

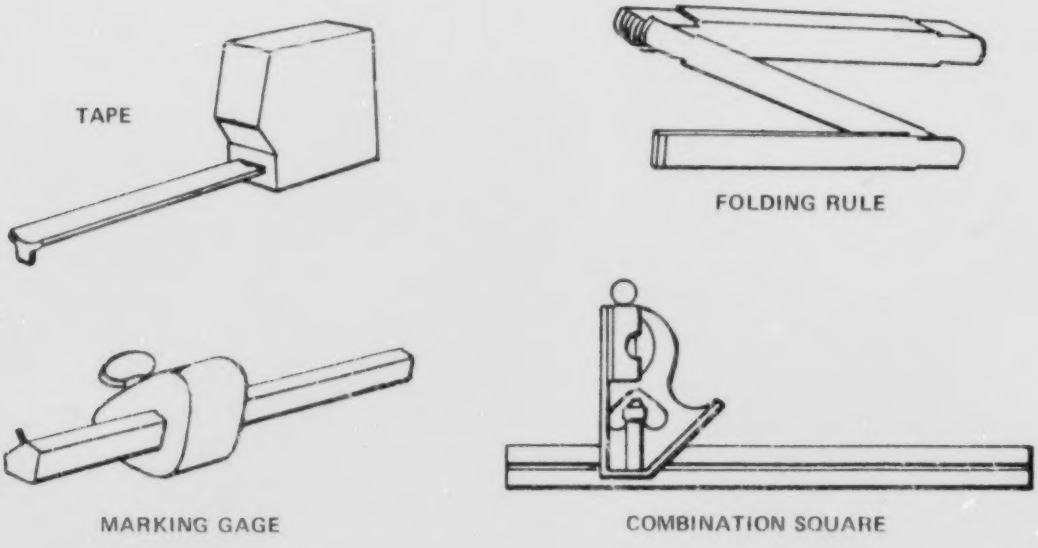
UNIT V – METRICS IN BUILDING TECHNOLOGY

Lesson 1 — **Metric Tools**

Objective: You should become aware of those tools which are measurement-sensitive and those which are not.

Changing to metrics in building technology will be easier than in many other trades. Length will usually be measured in centimetres or metres. Some of the tools of the trade will have to be replaced with metric tools, but others will work well with either the metric system or the customary system.

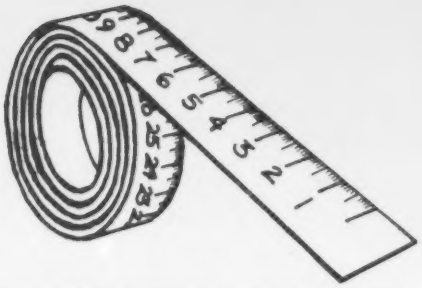
Some of the measuring tools that will have to be replaced are the tape measure, folding rule, marking gage, and square. When possible, replace them with measuring tools that have both the metric and customary units.



Tools to be replaced

Do not replace all the customary-system measuring tools immediately. Some tools will not need to be replaced. These tools are adjustable. It will be a matter of properly adapting the tool.

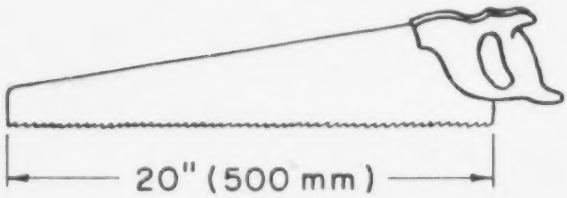
For example, all woodworking machines are adjustable for depth and width of cut. Don't buy a new machine unless the old machine is worn out. Buy some pressure-sensitive metric tape to cover or place alongside the units of the customary system. This tape can be used to change the gages on power saws, planers, jointers, etc. to metric or to combination metric and customary units.

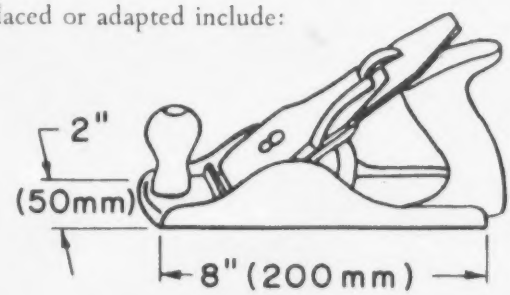


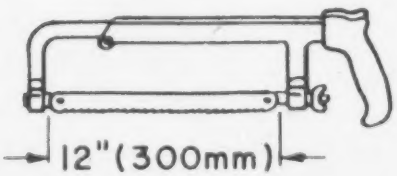
PRESSURE-SENSITIVE METRIC TAPE

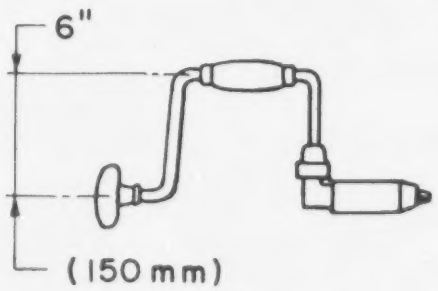
Manufacturers may make small changes in the sizes of tools when they change to the metric system. You will not have to replace or adapt tools which are not measurement-sensitive. For example, there is a small difference between a 24" and a 600 mm level, but either level can be used for the same tasks.

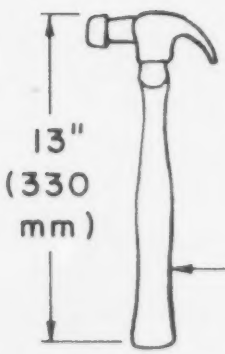
Other tools that will not have to be replaced or adapted include:



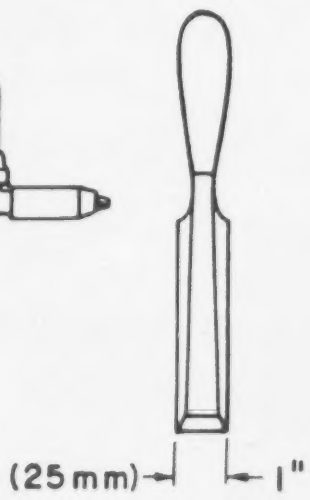








WEIGHT 16 oz. (450 gm)



Tools that will not be replaced

What other tools in building technology can you add to this list?

We will have new charts to work with as metric standards are developed for the United States. A new set of metric drills is probably one of the first tool changes that you will make.

Questions:

1. List some building-technology tools that will have to be replaced immediately when we implement the metric system. Why do we call them measurement-sensitive?

2. List some building-technology tools that can be inexpensively adapted to the metric measurements. How?

3. List some building-technology tools that will not have to be replaced. Why?

4. Give some examples of how the implementation of metric measurements will affect:

    a. Carpentry
    b. Masonry
    c. Roofing
    d. Sheet Metal

UNIT V – METRICS IN BUILDING TECHNOLOGY

Lesson 2 **Metric Standards**

Objective: You should be aware that new standards with metric dimensions are presently being developed in the United States.

Metric standards are being developed in various areas for use in the United States. While the sizes will be measured metrically, some of the standards of fit, etc. may actually differ in various parts of the world.

For example, the Industrial Fasteners Institute trial standard IFI-500 is a system of screw threads for metric-series internally and externally threaded fasteners. The IFI designated the IFI-500 as a *trial* standard to warn both producers and users that the standards may change.

In some cases we may wish to look at the standards used by other industrial countries using the metric system. The British Standards for Lumber in the Appendix is one example. It shows the metric lumber lengths, widths, and thicknesses that have been adopted in Great Britain. The lengths increase in units of 300 mm (very close to a foot), and the width in units of 25 mm (very close to an inch). The materials are sold in metric lengths, widths, and thicknesses, but the dimensions are approximately what they were in the past.

Metric lumber standards have not been determined for the United States, but they will probably be close to those accepted by Great Britain. For example, we might adopt a 19 mm size for the 3/4″ standard. The 25 mm size is so close to 1″ that it will probably be the replacement standard. Each standard will have to be thought out carefully in the light of building requirements.

We are living through an exciting time of change in respect to measurement. Changing to the metric system gives us a once-in-a-lifetime chance to re-evaluate our standards and to "clean house" if necessary. It would be very easy to change a 2X4 to 50 mm X 100 mm (slightly smaller), but should the present 2X4 be the same, smaller, or larger *in respect to building needs?* This is an excellent opportunity to make the changes that are needed.

Questions:

1. Think carefully. What changes would *you* make in various standards in building technology?

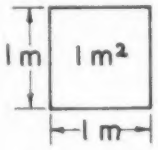
UNIT VI – AREA

Lesson 1 — **Units of Area**

Objectives

1. You should be able to write, from memory, the common SI units of area.
2. You should be able to state the SI base unit for area.
3. You should be able to state the relationship of each unit to the base.
4. You should be able to write the symbol for each unit.

Every plane figure has an area. In the SI metric system the base unit is the square metre (m^2). The square metre is classified as a *derived unit* because it is a result of multiplying the base unit (metre) by itself.



Common Units of Area

Unit	Relationship to Base	Symbol
square kilometre	1 000 000 m^2	km^2
square metre	base unit	m^2
square decimetre	1/100 or 0.01 m^2	dm^2
square centimetre	1/10,000 or 0.0001 m^2	cm^2
square millimetres	1/1,000,000 or 0.000 001 m^2	mm^2

In the next lesson we will discuss why there are 1 000 000 m^2 in one square kilometre even though "kilo" means 1000.

Notice that area is always expressed in square units.

In 1879 the International Committee of Weights and Measures (CIPM) adopted two units of area called the **are*** and the **hectare****. The hectare is not officially an SI unit but is recognized as a unit that is commonly used, especially in real estate.

* pronounced AIR

** pronounced HEK-tair.

Unit	Relationship to Base	Symbol
are	100 m^2	a
hectare	10 000 m^2	ha

"Hecto" is an SI prefix meaning 100 times. Therefore, "hectare" means 100 ares or (100) (100m^2) = 10 000 m^2.

Questions:

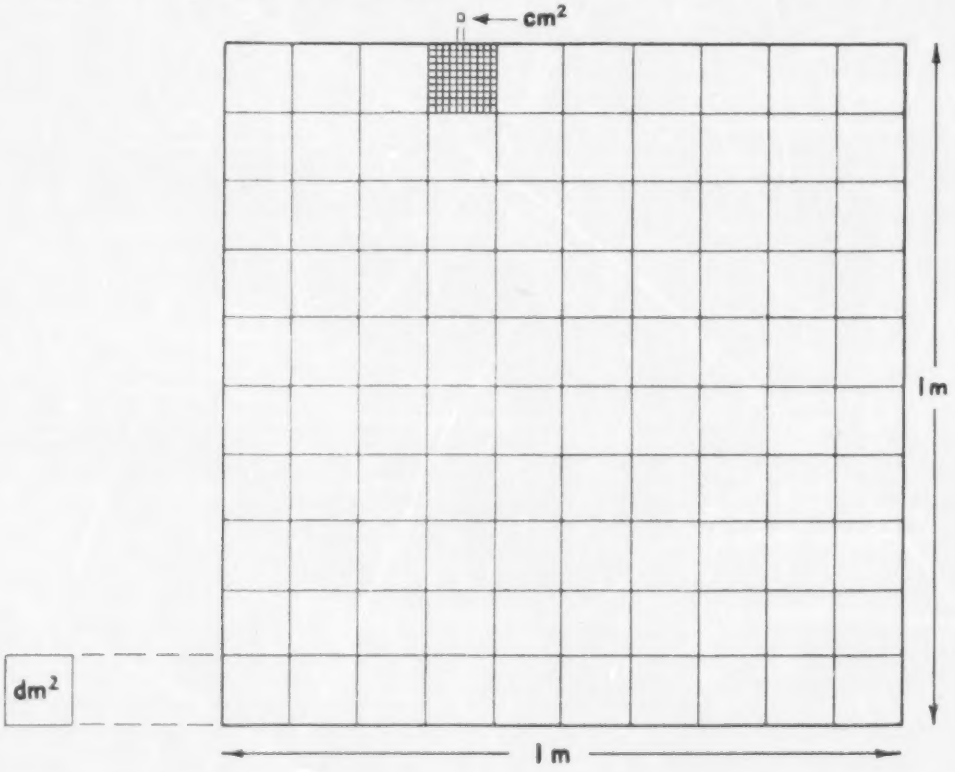
1. What is the SI base unit for area?
2. Name the five SI units of area plus the two recognized units from memory.
3. How many square metres are in one square kilometre?
4. How many square centimetres are in one square metre?
5. How many square millimetres are in one square metre?
6. How many square decimetres are in one square metre?
7. How many square metres are in one hectare?
8. Write the symbols for the six units of area mentioned in this lesson.

Lesson 2 **Conversions Within SI Units of Area**

Objectives: You should be able to change from one unit of area to another within the metric system.

In the previous lesson we promised to discuss here why there are 1 000 000 square metres in 1 square kilometre. Before we do that, let's take a look at another equivalent measure – one that can be illustrated on a page of this book.

We will illustrate how there are *10 000 square centimetres in 1 square metre.* The idea is the same for all the square measures.



The large square represents *one square metre.* Each edge has been divided into 10 *decimetres.* You can see that there are 100 square decimetres in the square metre. Now look at the square decimetre that is marked off in *square centimetres.* There are 100 square centimetres in the one square decimetre, and 100 square decimetres in the one square metre. So there are 100 × 100, or 10 000 square centimetres in the square metre.

Now we'll show the same thing mathematically. We know that

$$100 \text{ centimetres} = 1 \text{ metre}$$

This is a simple *equation.*

We are interested in *square* metres now. To get 1 square metre from 1 metre, we multiply it by itself. That's what *squaring* means. By the laws of mathematics, if we square the quantity on one side of an equation (1 metre), we must square the quantity on the other side of the equation also. Doing this, we get

$$(100 \text{ cm})\ (100 \text{ cm}) = (1 \text{ m})\ (1 \text{ m})$$

$$10\,000 \text{ cm}^2 = 1 \text{ m}^2$$

In the same way, from the fact that

$$1000 \text{ metres} = 1 \text{ kilometre}$$

we get

$$(1000 \text{ m})\ (1000 \text{ m}) = (1 \text{ km})\ (1 \text{ km})$$

$$1\,000\,000 \text{ m}^2 = 1 \text{ km}^2$$

The following chart summarizes the most important equivalents in square measure.

1 square metre	= 1 000 000 square millimetres
1 square metre	= 10 000 square centimetres
1 square metre	= 100 square decimetres
1 square kilometre	= 1 000 000 square metres
1 hectare	= 10 000 square metres

Examples:

1. Express 650 square decimetres in square metres.

Solution: a. A square decimetre is *smaller* than a square metre.

b. In changing a smaller unit to a larger unit, we always *divide,* i.e., move the decimal point *to the left.*

c. 1 square metre = 100 square decimetres. We therefore divide by 100, i.e., move the decimal point *2 places to the left.*

650 square decimetres = 6.5 square metres

2. Express 3 square kilometres in square metres.

Solution: a. The km^2 is the larger unit.

b. Larger unit to smaller unit – *multiply*
(Move the decimal point to the right.)

c. 1 square kilometre = 1 000 000 square metres
Therefore, multiply by 1 000 000.
(Move the decimal point *6 places to the right.)*

3 square kilometres = 3 000 000 square metres

3. Express 3562 square metres in hectares.

Solution: a. The m^2 is the smaller unit.

b. Smaller unit to larger unit – *divide*
(Move decimal point to left.)

c. 1 hectare = 10 000 square metres
Therefore, divide by 10 000
(Move decimal point *4 places to the left.)*

3562 square metres = 0.3562 hectares

Questions:

1. *Centi* means 1/100. Yet there are 10 000 square centimetres in 1 square metre. Explain this seeming inconsistency.

2. How many square millimetres are there in one square centimetre? in one square decimetre?

3. How many square centimetres are there in one square decimetre?

4. Express 675 cm^2 in square metres.

5. Express 25 cm^2 in square millimetres.

6. Express 0.035 km^2 in square metres.

7. Express 14 215 m^2 in hectares.

8. Express 555 cm^2 in square metres.

9. Express 3752 mm^2 in square centimetres.

10. Express 4750 m^2 in square kilometres.

11. Express 1 032 500 cm^2 in square metres.

12. Express 7.032 cm^2 in square millimetres.

13. Express 3411 m^2 in hectares.

14. Express 721.5 ares in hectares.

15. Express 5 321 722 m^2 in hectares.

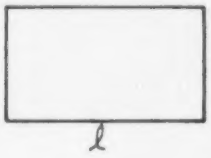
Lesson 3 — Area of a Rectangle, Triangle, Trapezoid

Objectives:

1. You should be able to state the area formulas for rectangles, triangles, and trapezoids from memory.

2. You should be able to calculate the area of rectangles, triangles, and trapezoids when sufficient information is given.

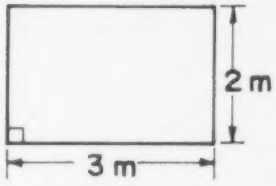
A rectangle is a four-sided plane figure with four right angles.



Rectangle

Area of a rectangle = length × width
or simply
$A = lw$

Example 1 – Rectangle



Find the area of the rectangle above in square metres and square centimetres.

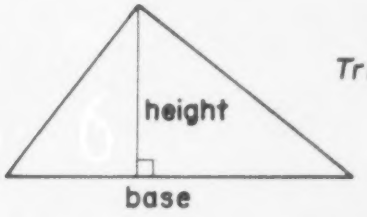
Solution:

$A = lw$

$A = (3\text{ m})(2\text{ m}) = 6\text{ m}^2$

$6\text{ m}^2 = 60\,000\text{ cm}^2$ (move decimal point 4 places to right)

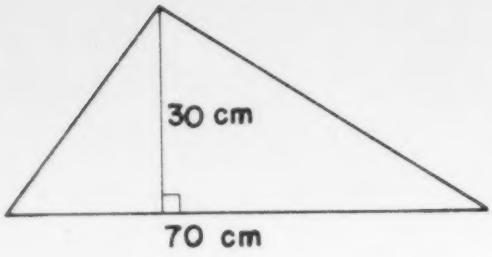
A triangle is a three-sided plane figure.



Triangle

Area of a triangle = .5 (base) (height)
or $A = .5bh$

Example 2 – Triangle



Find the area of the triangle above in square centimetres, square millimetres, and square metres.

Solution:

$A = .5bh$

$A = .5(70\text{ cm})(30\text{ cm})$

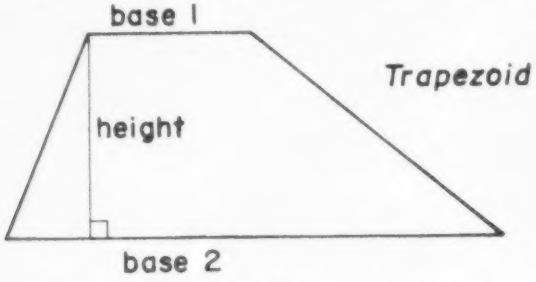
$= (35\text{ cm})(30\text{ cm})$

$= 1050\text{ cm}^2$

$1050\text{ cm}^2 = 105\,000\text{ mm}^2$ (move decimal point 2 places to right)

$1050\text{ cm}^2 = 0.105\text{ m}^2$ (move decimal point 4 places to left)

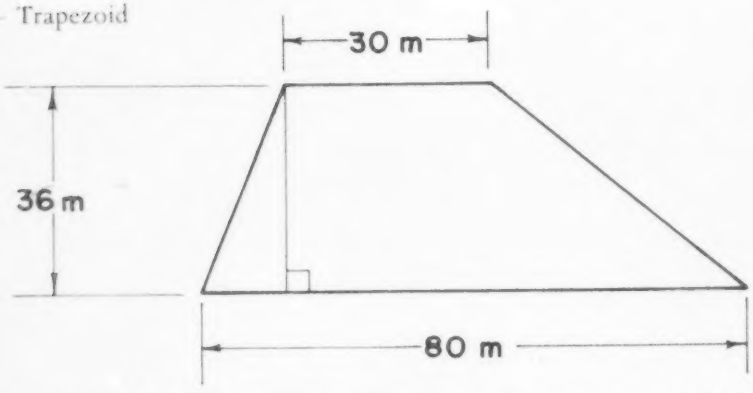
A **trapezoid** is a quadrilateral (4-sided plane figure) with exactly 2 sides parallel.



Area = .5 (height) (base 1 + base 2)

or $A = .5h(b_1 + b_2)$

Example 3 – Trapezoid



Find the area of the above trapezoid in square metres, ares, and hectares.

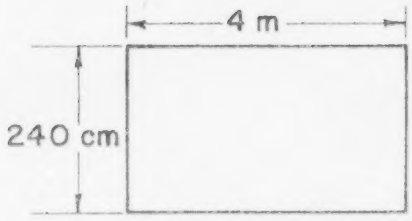
Solution:

$$A = .5h(b_1 + b_2)$$
$$A = .5(36\text{ m})(30\text{ m} + 80\text{ m})$$
$$A = (18\text{ m})(110\text{ m})$$
$$A = 1980\text{ m}^2$$
$$1980\text{ m}^2 = 19.8\text{ a (move decimal point 2 places to left)}$$
$$1980\text{ m}^2 = 0.198\text{ ha (move decimal point 4 places to left)}$$

Caution:

In working out area problems, be sure to use *the same unit* when multiplying the different dimensions. If the dimensions are not given in the same unit, convert one or the other by moving the decimal point.

Example:



Solution:

The area formula for a rectangle is $A = lw$. We cannot continue until we have both units the same. In this case it will be easier to work the problem if we change 240 cm to metres.

$$240\text{ cm} = 2.4\text{ m}$$

Therefore,

$$A = (4\text{ m})(2.4\text{ m})$$
$$A = 9.6\text{ m}^2$$

(We could have changed 4 metres to 400 centimetres, but we'd have been bothered with a lot of extra zeros in multiplying. And the answer is better stated as 9.6 m^2 than as 96 000 cm^2.)

Problems:

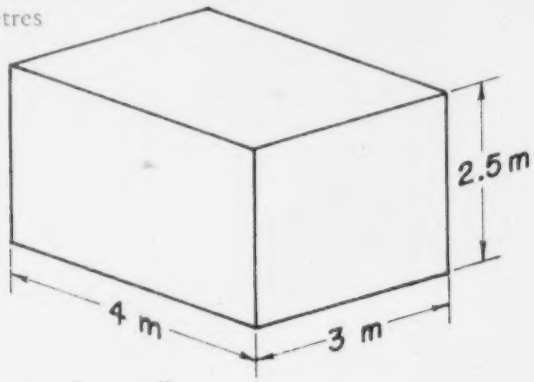
1. What is the area formula for a rectangle?

2. What is the area formula for a triangle?

3. What is the area formula for a trapezoid?

4. A rectangle has the dimensions 11 cm by 13 cm. What is its area?

5. The four walls of a room are rectangular in shape. The dimensions of the room are 3 metres by 4 metres by 2.5 metres



   a. Find the total area for the four walls.

   b. Find the area of the ceiling.

   c. If a 4-litre can of paint covers 42 m^2, then how many cans are needed to apply 2 coats to the four walls?

   d. Using the same type of paint, how many cans are needed to apply 2 coats to the ceiling?

6. What would be the answer to 5(c) if a door that is 1 m X 2 m and 3 windows, each 90 cm X 150 cm are subtracted from the wall area?

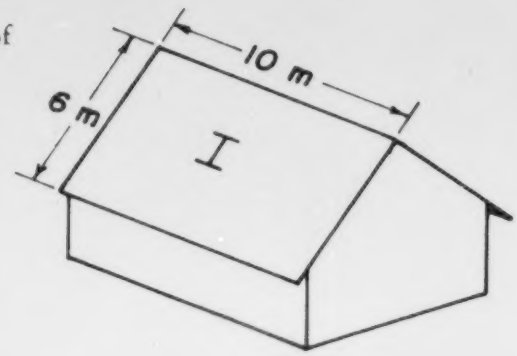
7. If the normal size for a metric building brick is 190 mm X 90 mm X 57 mm, then approximately how many bricks will there be in one square metre if the bricks are laid flat? (Assume there will be 10 mm of mortar between bricks.)

8. A house is located on a rectangular lot 45 m X 60 m.
   Express the area of this lot:

   a. in square metres

   b. in hectares

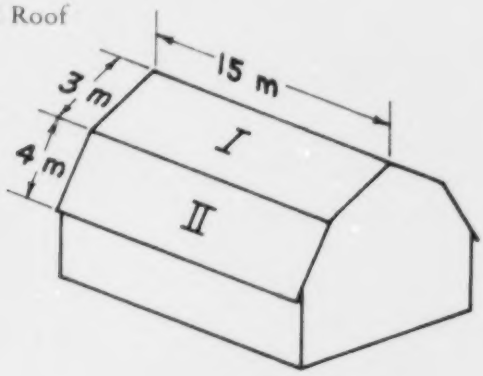
9. Gable Roof



a. The area of rectangle I is _____

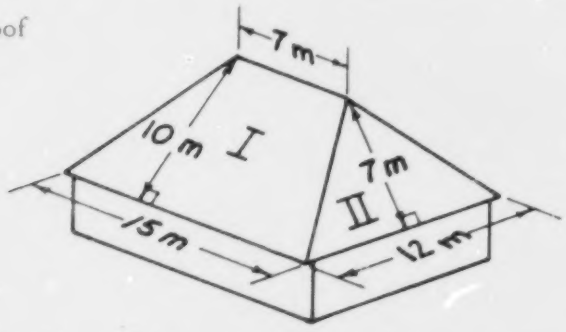
b. The total area of this gable roof is _____

10. Gambrel Roof



The total area of this gambrel roof is _____

11. Hip Roof



a. Two of the sides of the hip roof are in the shape of a trapezoid. The area of trapezoid I is _____

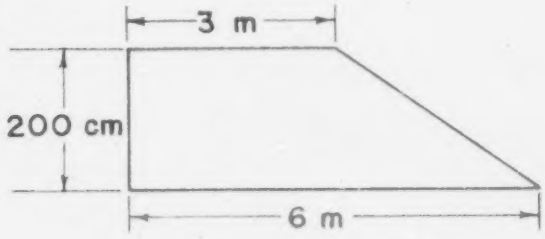
b. The area of triangle II is _____

c. The total area of the roof is _____

12. If shingles cost $16.00 a package and one package covers 9 square metres, then how much would it cost to shingle the gable roof in problem 9?

13. Using the same figures for the cost and coverage of shingles, compute the cost to shingle the gambrel roof in problem 10.

14. Compute the cost to shingle the hip roof in problem 11.

15. 

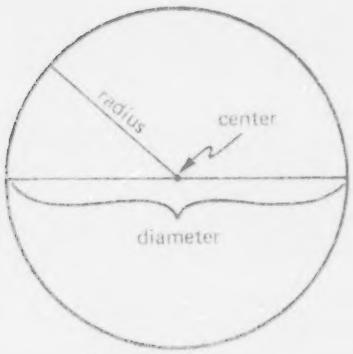
Find the area in square metres.

Lesson 4 — Area of a Circle

Objectives:

1. You should be able to define the radius of a circle.
2. You should be able to state from memory the formula for the area of a circle.
3. You should be able to use the area formula of a circle to solve area problems involving circles.

A circle is a set of points equidistant from a given point, the center.

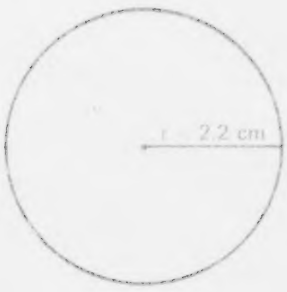


The radius of a circle is the distance from the center to a point on the circle.

The formula for the area of a circle is:

$$A = \pi r^2$$

Example:



Find the area of the above circle.

$$A = \pi r^2$$

using $\pi = 3.14$

$$A = (3.14)(2.2\text{ cm})^2$$

$$= (3.14)(4.84\text{ cm}^2)$$

$$= 15.2\text{ cm}^2 \text{ (rounding off to the tenths place)}$$

Problems:

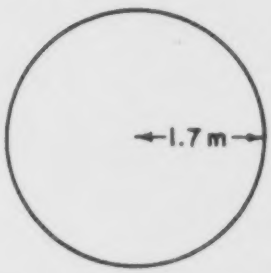
1. Define the radius of a circle.

2. State the formula for the area of a circle from memory.

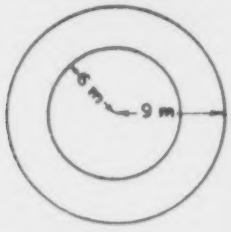
3. Find the areas of the following circles (use 3.14 for π).

Radius in mm	Area in mm^2	Area in cm^2
a. 12		
b. 15		
c. 25		
d. 30		
e. 35		
f. 100		

4. A mason was told to lay out a circular base for a water fountain. The distance from the center to the edge was to be 1.7 metres. What was the area of the circular base?



5. A circular walk around a display in a park was laid out using a 9-metre radius for the outer edge and a 6-metre radius for the inner edge. Calculate the area of the inner circle. Calculate the area of the outer circle. Now subtract the area of the inner circle from the area of the outer circle. The difference is the area of the sidewalk.



Inner area _____

Outer area _____

Area of walk _____

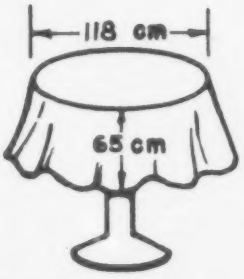
6. What is the area of the largest circle that can be cut from a piece of fabric 90 centimetres square? What is the area of the fabric that is not in the circle? (Hint: Draw a sketch).

_____

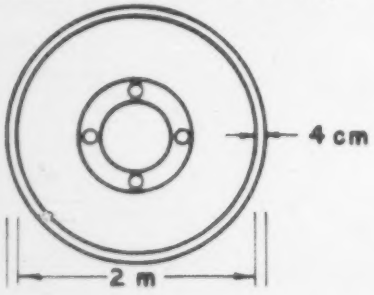
_____

7. What is the area of a wheel with a 54-centimetre diameter? _____

8. What is the area of a circular tablecloth needed to cover the table shown here if the cloth is to hang down 65 centimetres?

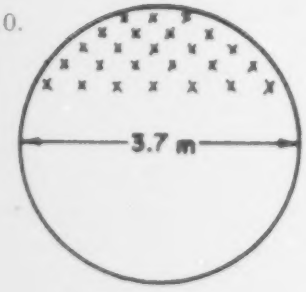


9. The diameter of a tank is 2 metres. How many square metres of metal are needed for a tank cover that is 4 cm wider than the tank all the way around? (Hint: Express the new diameter in terms of metres, using a decimal. Then find the radius.)



_____

_____

10. 

A landscape gardener laid out a circular bed for begonias that was 3.7 metres across. What was the area of the bed?

_____

If the gardener figured on 16 plants for each square metre, how many plants would he need?

_____

11. What is the area of a piston whose diameter is 8.76 centimetres? (Use 3.1415 for π.)

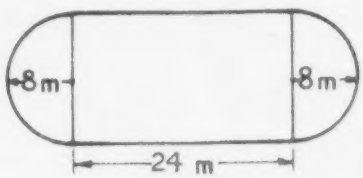
_____

12. For calculating the number and sizes of outlets needed in the various rooms of a house, a heating contractor needed to know the areas of circular ducts. Find the area of (a) a 15-centimetre (diameter) duct; (b) a 19-centimetre duct.

(a)_____

(b)_____

13. Calculate the area that is bounded by the track below.

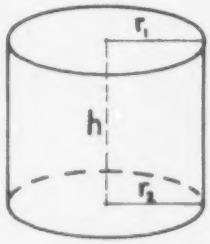


Lesson 5 — Lateral Surface Area

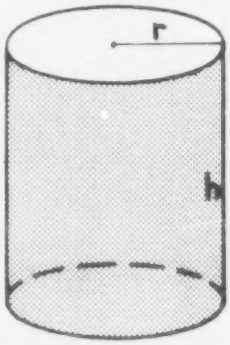
Objectives:

1. You should be able to identify lateral surface area.
2. You should be able to state from memory the formula for the lateral surface area of a right circular cylinder.
3. You should be able to utilize this formula to solve area problems.

A right circular cylinder is a cylinder where a line segment (h) joining the centers of the circular bases is perpendicular to the radii (r_1 and r_2) of each base.

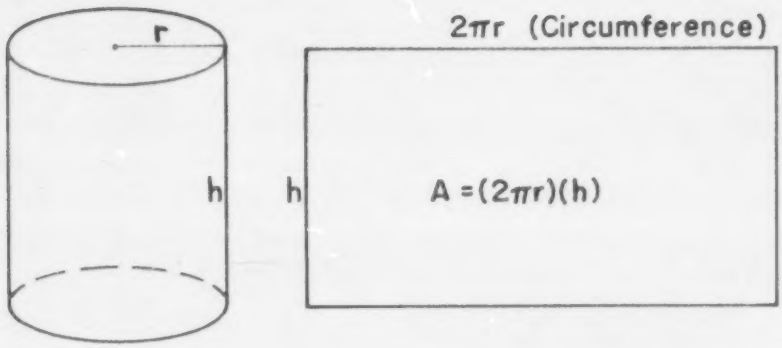


The lateral surface area of a right circular cylinder is the area of the side of the figure (shaded region).



If, for example, we removed the label from a can of food and we laid it out flat, we would find that the label would be in the shape of a rectangle.

The area of this rectangle, which is actually the same as the lateral surface area of the can, is equal to the length times width. The length is $2\pi r$, the circumference of the top of the can, and the width is "h", the height of the can.



Therefore $A = 2\pi rh$

Caution: As before, make sure all dimensions are in the *same unit* before working the problem.

Problems:

1. Draw a right circular cylinder. Shade in the lateral surface area.

2. State the formula for the lateral surface area of a right circular cylinder from memory.

3. Could we use the formula $A = \pi dh$? Explain.

4. Complete the following table:

	Radius	Height	Lateral surface area
a.	5 mm	12 mm	
b.	5 mm	4 cm	
c.	3.2 cm	3.7 cm	
d.	50 mm	0.5 m	
e.	1 m	1.5 m	

5. A piece of tubing has an outside diameter of 5 mm and is 7 m long. What is the lateral surface area?

6. A painter must paint a large tank in the shape of a right circular cylinder. The radius of the tank is 8 m and the height is 10 m. How many 4-litre cans of paint are needed to cover the lateral surface area and the top with one coat of paint if 1 can covers 40 m^2?

UNIT VII – VOLUME

Lesson 1 **Units of Volume**

Objectives:

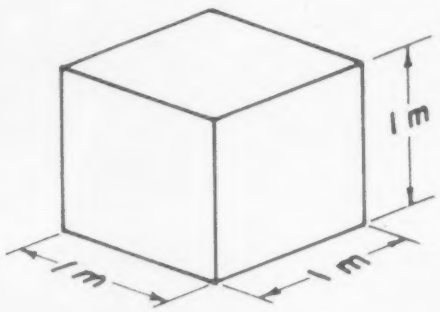
1. You should be able to write, from memory, the common SI units of volume and their symbols.

2. You should be able to state the SI base unit for volume.

3. You should be able to explain the relationship of two other units of volume to the base unit.

In this chapter we will discuss three-dimensional figures and their volume. By volume we mean a number which represents the amount of space enclosed by the figure. This number will always be expressed in cubic units.

The base unit for volume is the cubic metre. A cubic metre is a space 1 metre × 1 metre × 1 metre



The common units for volume are all derived units.

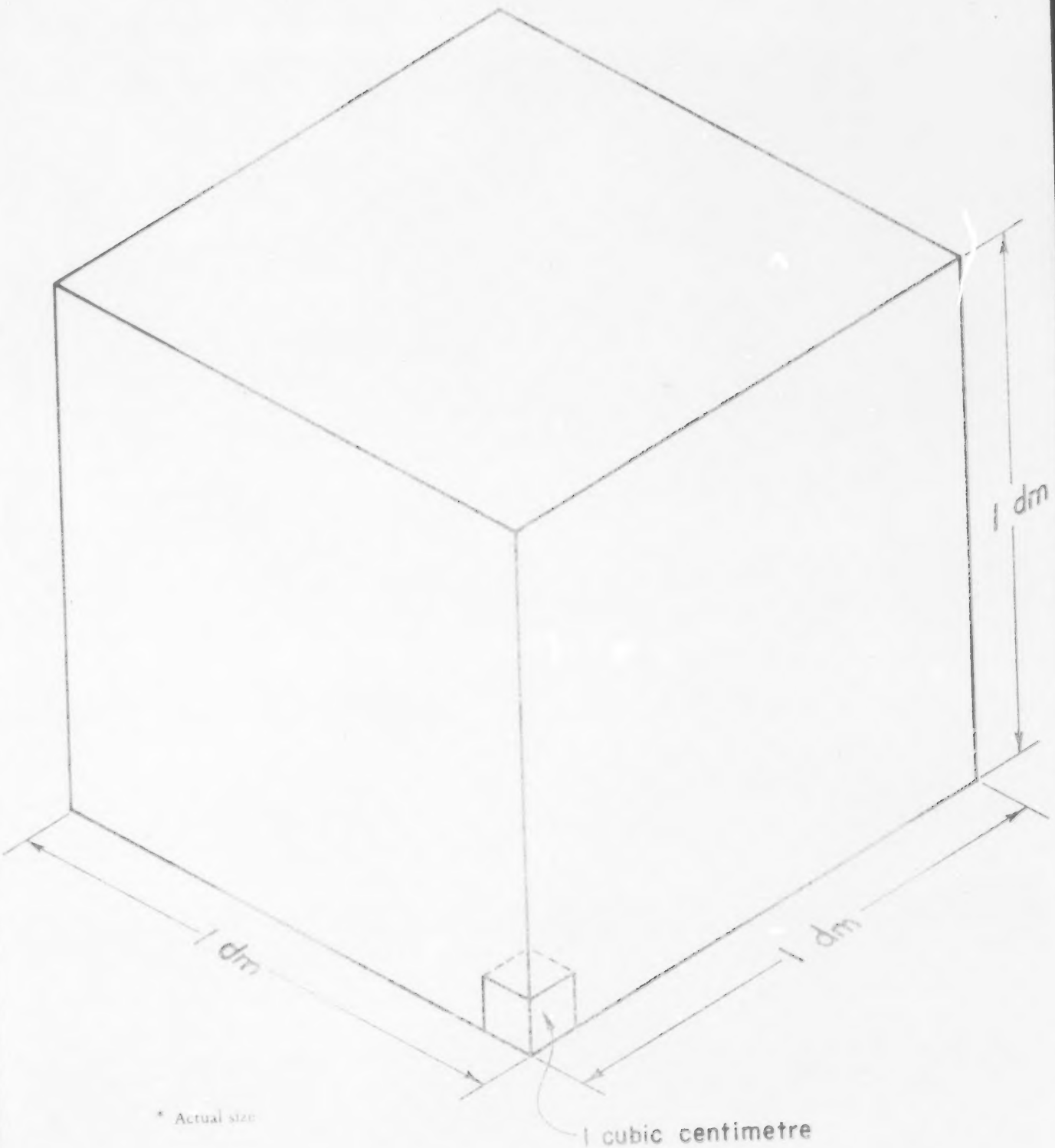
Unit	Relationship to base	Symbol
cubic metre		m^3
cubic decimetre	1/1000 or 0.001 m^3	dm^3
cubic centimetre	1/1,000,000 or 0.000 001 m^3	cm^3

You will sometimes see the symbol cc used in place of cm^3 for the displacement of small automobile engines, motorcycle engines, and other small volumes. It may also be used in the medical profession in measuring drug doses and other small quantities of liquid. The symbol cc is not an SI symbol.

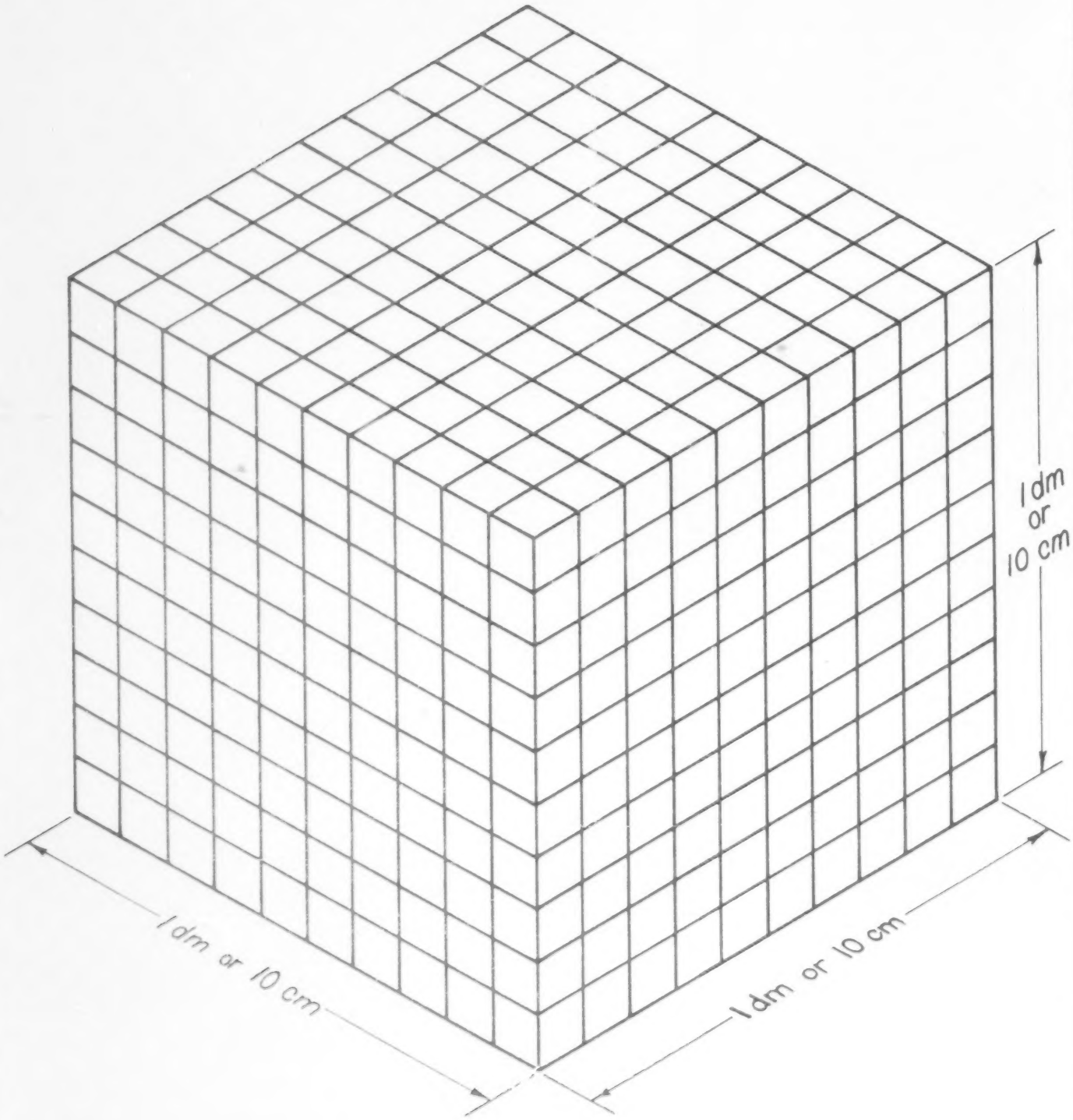
On the next page is an illustration of the actual size of a cubic decimetre. This unit of volume is important because it is equal to an everyday unit called the litre. The litre will be discussed in the next lesson.

On page 86 is a drawing which illustrates the fact that one cubic decimetre equals 1000 cubic centimetres.

One Cubic Decimetre*



* Actual size



One cubic decimetre = one thousand cubic centimetres

Questions:

1. What is the SI base unit for volume?
2. What are the three common units of volume mentioned in this lesson?
3. How many cubic decimetres are there in one cubic metre?
4. What fractional part of a cubic metre is one cubic decimetre?
5. How many cubic centimetres are there in one cubic metre?
6. What fractional part of a cubic metre is one cubic centimetre?
7. How many cubic centimetres are there in one cubic decimetre?
8. Construct a cubic decimetre out of paper or cardboard.
9. Write from memory the SI symbols for the three units of volume mentioned in this lesson.
10. Class project: construct a cubic metre using dowels, cardboard, or other available material.

Lesson 2 — The Litre

Objectives:

1. You should be able to state the name of the SI derived unit of volume that the litre is equal to.

2. You should be able to write, from memory, 2 units based upon the litre, and their symbols.

3. You should be able to state the relationship of each unit to the litre.

The following declaration was made at the third General Conference on Weights and Measures (CGPM) in 1901.

> The unit of volume, for high accuracy determinations, is the volume occupied by a mass of 1 kilogram of pure water, at its maximum density and at standard atmospheric pressure; this volume is called "litre."

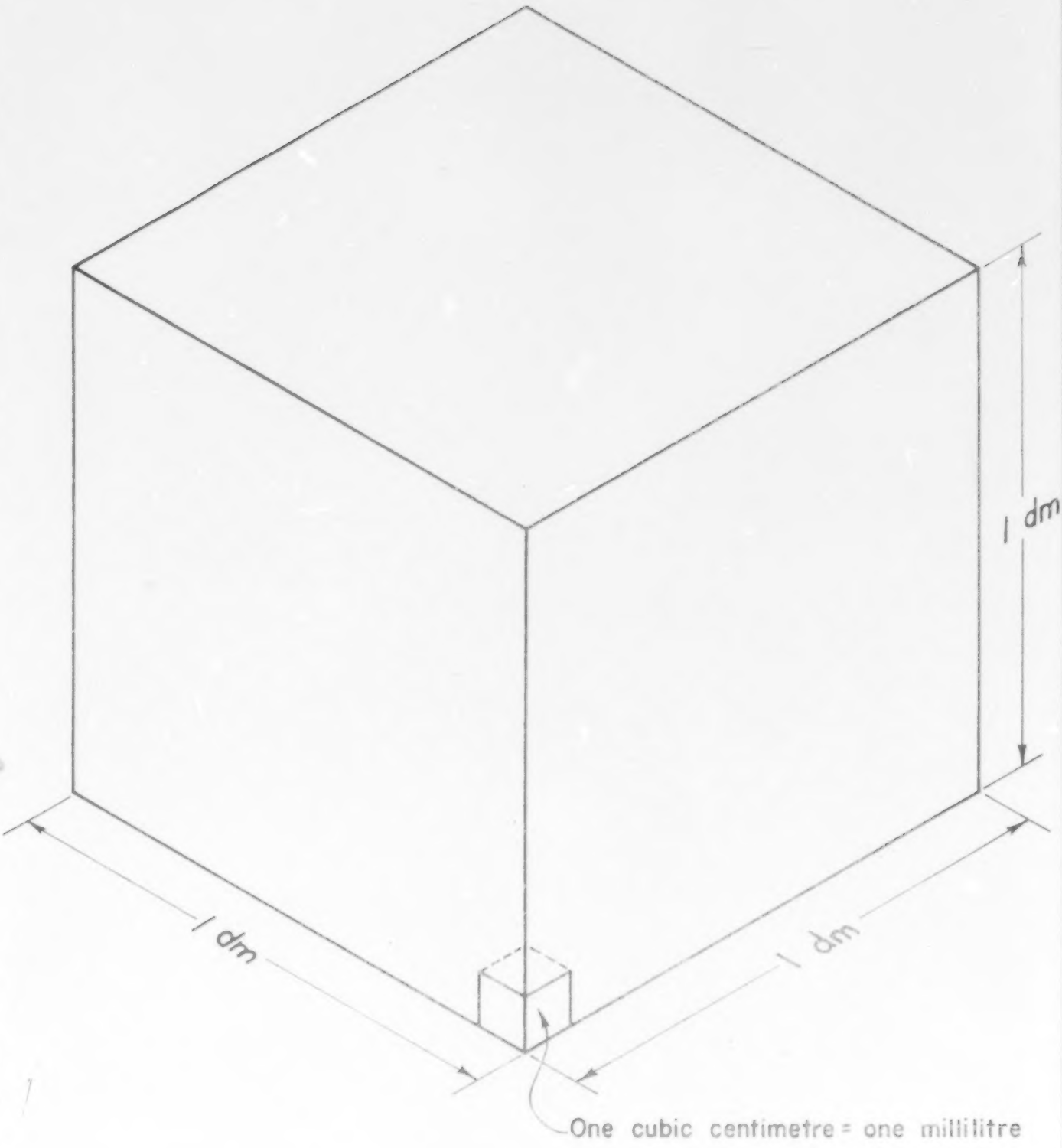
The above definition of a litre made it almost identical in size to a cubic decimetre.

At the 11th CGPM in 1960, it was officially recognized that the cubic decimetre and the litre as defined in 1901 were unequal and differed by about 28 parts in 1 000-000. Furthermore, as measurements of volume become more accurate, there was increased risk of confusion between the volume of a cubic decimetre and a litre.

Finally, at the 12th CGPM in 1964, the definition of litre given in 1901 was abrogated. The word "litre" was declared to be a special name for the cubic decimetre. Therefore,

1 litre = 1 cubic decimetre

Although all the prefixes we have previously learned may be used with litres as with the other units of measure, only *milli* and possibly *kilo* are expected to be commonly used.



One cubic decimetre = one litre

Unit	Relationship to litre	Symbol
kilolitre	1000 litres	kl
litre		l or ℓ or L*
millilitre	1/1000 or 0.001 litre	ml

As mentioned above, 1 litre = 1 cubic decimetre. If these two are equal and we take the same fractional part of each, then the results must be equal to each other.

1/1000 litre = 1/1000 cubic decimetre

or

1 millilitre = 1 cubic centimetre

The litre is commonly used to measure the volume of liquids. Items once marked in fluid ounces, cups, pints, quarts, gallons, or barrels will now be measured in litres or one of the units based on the litre. Also, piston displacement in automobile engines is occasionally measured in litres.

Questions:

1. To what SI derived unit is the litre equal?
2. To what unit is the millilitre equal?
3. Write, from memory, 2 units based upon the litre.
4. How many litres are there in one kilolitre?
5. How many millilitres are there in one litre?
6. What part of a litre is one millilitre?
7. How many cubic centimetres are there in one litre?
8. From memory, write the symbols for the 2 units mentioned in this lesson based on the litre.
9. Is L^3 a proper symbol? Explain.

Class Project

10. Estimate the contents of various cans, bottles, and other containers. Then fill them with water and measure the water in standard measuring containers.

* See footnote on page 20

UNIT VII – VOLUME

Lesson 3 **Conversions Within Units of Volume**

Objectives:

1. You should be able to convert from one SI unit of volume to another by properly multiplying or dividing.

2. You should be able to convert from SI units of volume to litres and their derived units.

In Lesson 1 of this chapter on volume we established that

1000 cubic centimetres = 1 cubic decimetre

1000 cubic decimetres = 1 cubic metre

1 000 000 cubic centimetres = 1 cubic metre

In Lesson 2 of this chapter we established that

1 litre = 1 cubic decimetre

1 millilitre = 1 cubic centimetre

1 kilolitre = 1000 litres

1 millilitre = 0.001 litre

In this lesson we will convert from one SI unit of volume to another, and from SI units to litres.

Remember that when we convert from *smaller units to larger units* we always *divide* (move the decimal point to the left), and when we convert from *larger units to smaller units* we always *multiply* (move the decimal point to the right).

Examples:

1. Express 400 cm^3 in cubic decimetres.

   a. When going from a smaller unit to a larger unit we divide (move the decimal point to the left).

   b. 1000 cubic centimetres = 1 cubic decimetre. Therefore, we must divide by 1000 (move the decimal point 3 places to the left).

$$400\ cm^3 = 0.4\ dm^3$$

2. Express 14 m^3 in cubic decimetres.

   a. When going from a larger unit to a smaller unit we multiply (move the decimal point to the right).

   b. 1000 cubic decimetres = 1 cubic metre. Therefore, we must multiply by 1000 (move the decimal point 3 places to the right).

$$14\ m^3 = 14\ 000\ dm^3$$

3. Express 0.5 litres in millilitres.

   a. When going from a larger unit to a smaller unit we multiply (move the decimal point to the right).

   b. 1000 millilitres = 1 litre
   Therefore, we must multiply by 1000 (move the decimal point 3 places to the right).

$$0.5 \text{ litre} = 500 \text{ millilitres}$$

4. Express 4326.1 dm^3 in cubic metres.

   a. When going from a smaller unit to a larger unit we always divide (move the decimal point to the left).

   b. 1000 dm^3 = 1 cubic metre
   Therefore, we must divide by 1000 (move the decimal point 3 places to the left).

$$4326.1\ dm^3 = 4.3261\ m^3$$

5. Express 798 dm^3 in litres.

   1 cubic decimetre = 1 litre
   Therefore,

$$798\ dm^3 = 798\ L$$

6. Express 15 cm^3 in terms of liquid measure.

   1 cm^3 = 1 millilitre
   Therefore,

$$15\ cm^3 = 15\ ml$$

Problems: Fill in:

1. 650.1 cubic decimetres = _____ litres.
2. 2500 cubic centimetres = _____ cubic metres.
3. 59 cubic centimetres = _____ cubic decimetres.
4. 50 cubic decimetres = _____ litres.
5. 500 millilitres = _____ litres.
6. 43.25 cubic centimetres = _____ millilitres
7. 200 litres = _____ cubic decimetres.
8. 2529 litres = _____ kilolitres.
9. 3 litres = _____ millilitres
10. 75 litres = _____ cubic decimetres
11. 75 litres = _____ cubic centimetres
12. 1200 cubic centimetres = _____ litres
13. 4.3 litres = _____ cubic centimetres
14. 4.5 cubic decimetres = _____ cubic centimetres
15. 2.13 cubic metres = _____ cubic decimetres
16. 900 millilitres = _____ litres
17. 25 000 cubic centimetres = _____ cubic decimetres
18. 0.25 cubic decimetres = _____ litres
19. 775 millilitres = _____ cubic decimetres
20. 0.91 millilitres = _____ cubic centimetres

21. MIX AND MATCH PUZZLE II
(Volume Measure)

On the next page you will see the sheet you are going to work on.

Cut the squares on this page apart. You are going to arrange these squares on the next page so that every measurement *has the same value* as the measurement adjacent (right next) to it. See the example below. When you are sure your solution to the puzzle is correct, paste or tape your squares down.

570 kl .04 ml 100 L 23 cm^3	23 m^3 40 ml .01 kl 570 dl	.057 kl 400 L .4 L 23 ml	.23 L 4 L .01 L 57 kl
570 cm^3 10 dl 40 cm^3 23 L	23 cl .1 kl 40 kl 2300 cm^3	2.3 cl 10 L 4 kl 570 L	57 ml 400 ml .01 ml 5.7 L
23 ml .4 ml 10 cl 570 ml	57 L 4 ml 1 ml 2.3 dl	.57 L 40 m^3 4 ml 57 L	5.7 dm^3 4000 L 400 kl 230 ml
.023 kl .01 ml 4 cm^3 .057 ml	2300 ml 1 dl 400 dm^3 23 kl	570 dm^3 1 cm^3 4 dm^3 .023 ml	23 kl 4 cm^3 .1 ml 5.7 cl

.01 kl	10 L	4 kl	4000 L
	570 L		
	570 dm^3		

SOLUTION TO MIX AND MATCH PUZZLE II

570 kl .04 ml 100 L 23 cm^3			

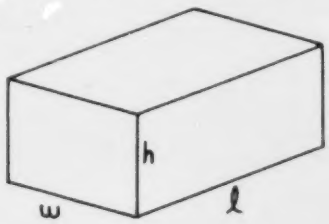
Lesson 4 **Volume of Rectangular Box and Cube**

Objectives:

1. You should be able to state, from memory, the volume formulas for a rectangular parallelepiped and a cube.

2. You should be able to utilize the formulas to solve volume problems, given enough information.

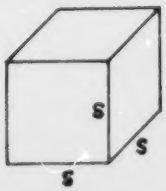
Volume of a box (rectangular parallelepiped in geometric terms):



Volume = length × width × height

or $V = lwh$

Volume of a cube:

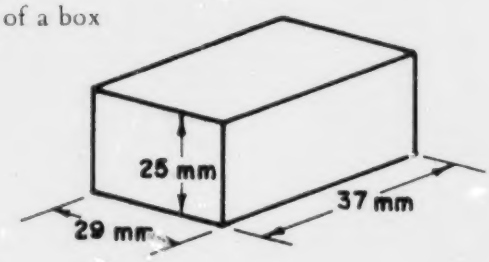


By definition, the length, width, and height of a cube are all equal. Therefore, letting *s* stand for each dimension,

Volume of a cube = s × s × s

$V = s^3$

Examples: Volume of a box

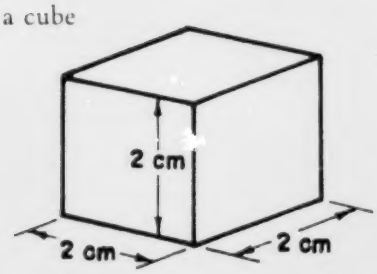


$V = lwh$

$V = (37\ mm)(29\ mm)(25\ mm)$

$= 26{,}825\ mm^3$

Volume of a cube



$V = s^3$

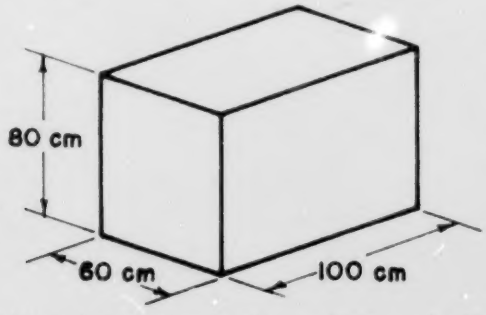
$V = (2\ cm)^3$

$= 8\ cm^3$

Problems:

1. State the volume formulas for a rectangular parallelepiped and a cube.

2. The length of one side of a cube is 7 cm. What is the volume of this cube in cubic centimetres?

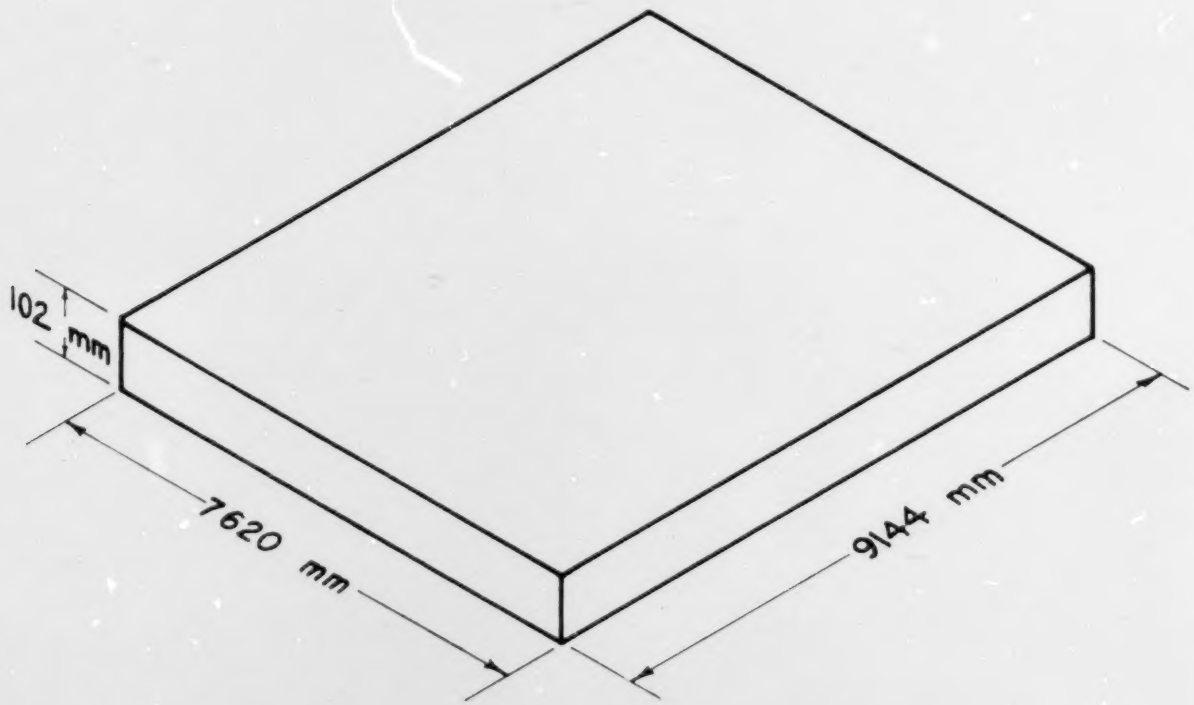
3. 

A fish tank is 100 cm long, 60 cm wide, and 80 cm high. What is the volume of the tank in cubic centimetres? in cubic decimetres? How many litres of water will it take to fill up the tank? (Disregard thickness of walls.)

4. A room is 2.75 metres wide, 3.66 metres long, and 2.44 metres high. What is the volume of this room?

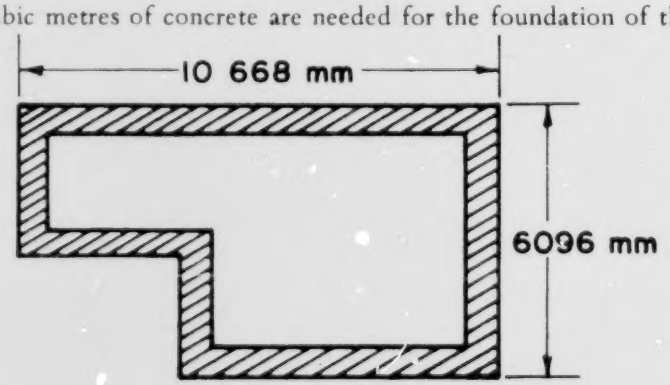
5. A box of cereal has dimensions 16 cm by 5 cm by 23 cm. What is the volume of the box in cubic centimetres?

6. The floor of a new house is going to be a concrete slab with dimensions 7620 mm by 9144 mm by 102 mm thick. How many cubic metres of concrete should be ordered? (In architectural drawings, the dimensions will be given in millimetres).



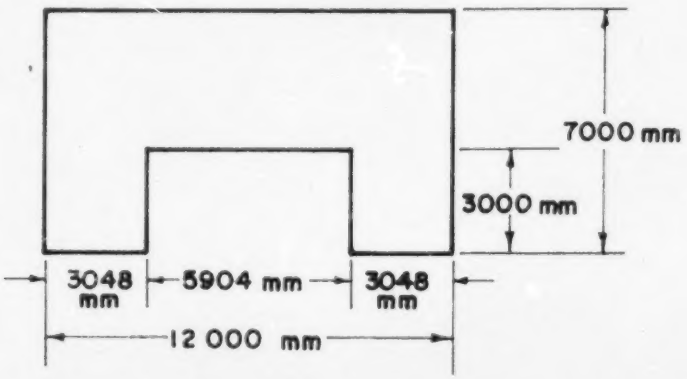
7. How many cubic metres of wood are there in a sheet of plywood 1200 mm by 2400 mm by 10 mm thick?

8. How many cubic metres of concrete are needed for the foundation of this house?



The foundation is to be 200 mm thick by 460 mm wide. Disregard overlapping on the corners.

9. How many cubic metres of earth must be removed for the cellar shown here if it is to be 2440 mm deep?



10. How many litres of water are there in one cubic metre?

11. A water tank is in the shape of a rectangular box. If the inner dimensions are 2 m X 1.5 m X 0.7 m, how many litres of water will it take to fill up the tank?

12. A patio is to be constructed 6.2 metres long, 4 metres wide, and 18 cm thick. How many cubic metres of concrete will be needed?

Lesson 5 Volume of a Right Prism and a Right Circular Cylinder

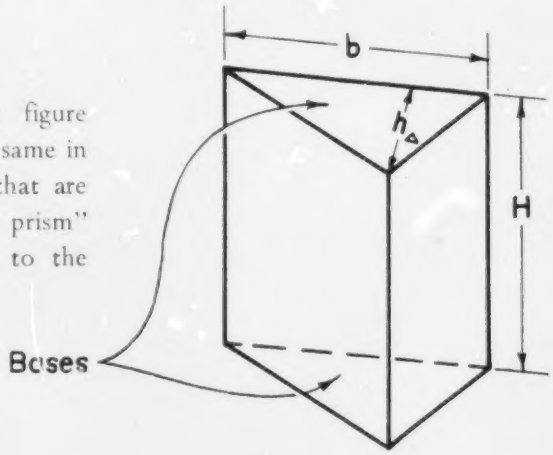
Objectives:

1. You should be able to state from memory the formulas for the volume of any right prism, of a right triangular prism, and of a right circular cylinder.

2. You should be able to utilize these formulas to solve volume problems, given enough information.

Volume of a right prism

A right prism is a geometric figure formed by two bases that are exactly the same in size and shape and having lateral sides that are rectangles. The word "right" in "right prism" means that the sides are perpendicular to the bases.



Volume of a right prism = area of base X height of prism

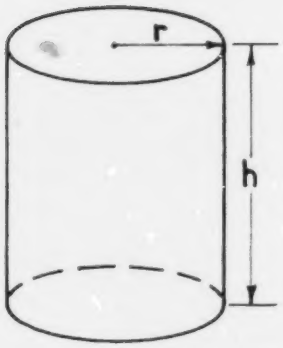
In the diagram above, the bases are both triangles. To calculate the volume, we must first find the area of one of the triangles. Then we will multiply this answer by the height of the prism in order to obtain the volume of the prism.

Let h_Δ stand for the altitude of the base triangle and H stand for the height of the prism. Then

$$V = (.5bh_\Delta)(H)$$

or $$V = .5bh_\Delta H$$

Volume of a right circular cylinder



Most of the cylinders we encounter in everyday life are of the type shown here. The bases are circles and the lateral surface meets the bases perpendicularly (at a right angle). For cylinders of this type we can use the same formula that we used for the right prism:

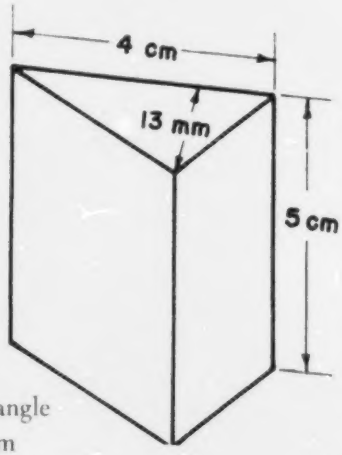
Volume of right circular cylinder = area of base × height

The base is a circle, and its area is $A = \pi r^2$ Therefore the volume is:

$$V = (\pi r^2)(h) \text{ or } \pi r^2 h$$

Examples:

(1) **Volume of a right prism**



Volume = area of base × height of prism

In this case, as on page 100 , the base is a triangle, and the area of a triangle is A = .5bh. Therefore the volume is:

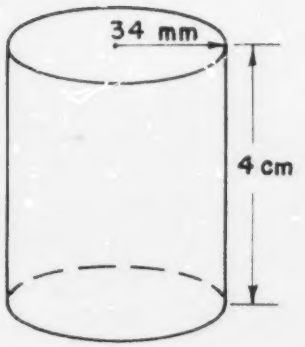
$$V = .5bhH$$

where h stands for the altitude of the triangle
and H stands for the height of the prism

Notice that the base of the triangle and the height of the prism are given in centimetres and the height of the triangle is given in millimetres. In order to proceed, we must change one or more dimensions so that all are in terms of the same unit. Looking at the problem, it seems sensible to work in centimetres and get an answer in cubic centimetres. We will therefore express 13 mm as 1.3 cm. Substituting the measurements in the formula, we get

$$V = (.5)\ (4\text{ cm})\ (1.3\text{ cm})\ (5\text{ cm}) = 13.0\text{ cm}^3$$
$$= 13\text{ cm}^3$$

(2) **Volume of a right circular cylinder**



V = area of base X height of prism

In this case the base is a circle with area = πr^2. Therefore the volume is:

$$V = \pi r^2 h$$

Again, we must change one of the dimensions. Since we would probably want our answer in cubic centimetres, we will express 34 mm as 3.4 cm. Substituting our measurements in the formula, we get

$$V = \pi(3.4 \text{ cm})^2(4 \text{ cm})$$

Using 3.14 as an approximation for π,

$$V = (3.14)(11.56 \text{ cm}^2)(4 \text{ cm})$$
$$= 145.1936 \text{ cm}^3$$
$$= 145 \text{ cm}^3 \text{ (rounded off)}$$

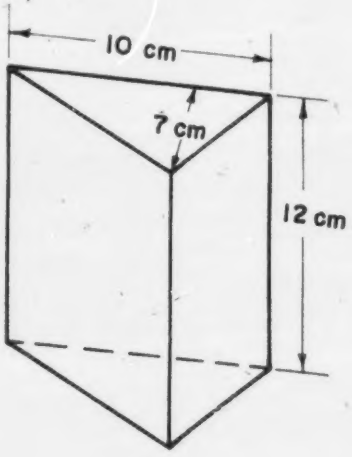
How much liquid would this container hold?

Since 1 cm^3 = 1 ml, the answer is 145 ml of liquid.

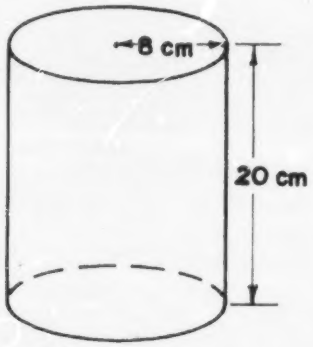
Problems:

1. a. Give the formula for the volume of any right prism.
   b. Give the formula for the volume of a right triangular prism.
   c. Give the formula for the volume of a right circular cylinder.

2. A right prism has a triangular base. If the base of this triangle is 10 cm, the height in relationship to this base is 7 cm, and the height of the prism is 12 cm, what is the volume of the prism?

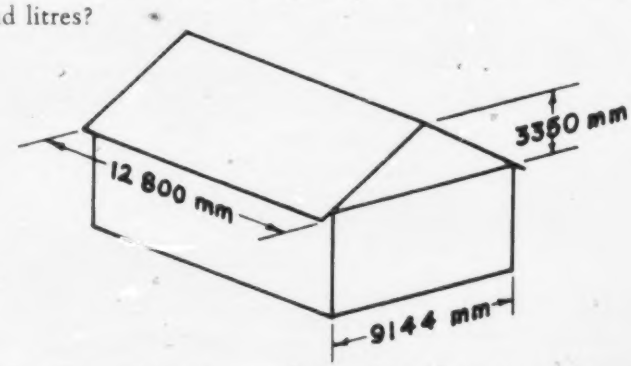


3. The interior radius of the base of a can of paint is 8 cm and the interior height is 20 cm. What is the capacity of the can when completely filled, in cubic centimetres? in cubic decimetres? in litres?



4. The interior radius of a can of oil is 5 cm, and the interior height is 14 cm. What is the capacity of the can when completely filled – in cubic centimetres, cubic decimetres, and litres?

5.



What is the volume in cubic metres of the attic of the house shown above? (Notice that the attic is in the shape of a right triangular prism.)

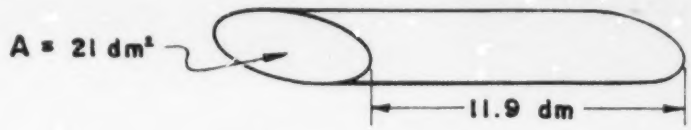
6. A small can of tuna fish has an interior radius of 42 mm and an interior height of 40 mm. What is the volume of this can in cubic centimetres?

7. A popular size can of soda has an interior radius of 32.5 mm and an interior height of 115 mm. What is the volume of the can in cubic centimetres? in litres?

8. A straight pipe has an inside diameter of 1 cm. What is the volume of a 2.5 m length of this pipe in cubic centimetres? in litres?

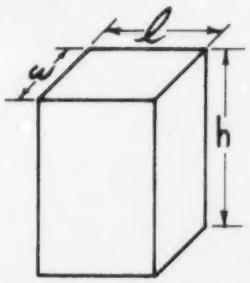
9. Suppose that the rate of flow of water through a pipe is 1 cubic metre/sec. If the inside diameter of the pipe is 6 cm, then how many litres of water will flow through the pipe in one hour? How many kilolitres is that?

10. The area of each base of a gas tank with oval ends is 21 dm^2 and the length of the tank is 11.9 dm. What is its capacity in litres?

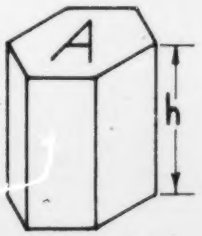


11. By using the formula for the volume of any right prism, show that the volume of the box shown is actually

$$V = lwh$$



12. What would be the volume of the storage bin shown here?



UNIT VIII – MASS or WEIGHT

Lesson 1 — **Units of Mass or Weight**

Objectives:

1. You should be able to explain a basic difference between mass and weight.
2. You should be able to write, from memory, the common SI units of mass and the symbol for each.
3. You should be able to state the SI base unit for mass.
4. You should be able to state the relationship of each unit to the base.

In any scientific discussion it is clear that mass and weight are different. *Weight* is based upon the attraction of gravity upon an object. Therefore, as gravity changes, so does the weight of an object. For example, a man's weight on the top of a mountain is not exactly the same as it is at sea level. On the surface of the moon, that same man weighs only about one-sixth his weight on earth!

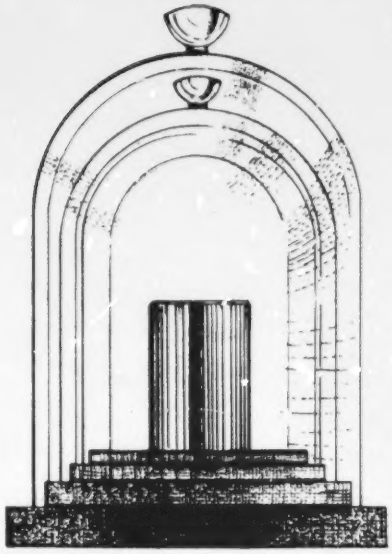
In contrast, the *mass* of a body – the amount of matter in it – is unchanging. The mass of an object is the same on earth as it is on the moon or anywhere else.

Since most people who use this book will not be flying off in a spaceship or climbing Mount Everest, we will use the word "weight" to mean "mass" in working practical problems.

The base unit for mass is the kilogram. It would seem that the gram should be the base unit, but using the gram would cause a problem because the gram is too small a unit for most practical purposes. The kilogram is the only base unit with a prefix in its name.

Originally the definition of the kilogram was based upon the mass of water under specific conditions. One kilogram was defined as the mass of 1000 cm^3 of pure water at 4°C (at water's maximum density) and under standard atmospheric pressure. Therefore the gram was one cubic centimetre of pure water at 4°C and under standard atmospheric pressure. Now 1000 cm^3 = 1 dm^3 = 1 litre. Therefore one litre of water under the conditions previously stated weighed one kilogram.

At the first CGPM in 1889 the kilogram was defined by a prototype (a physical model) made of platinum-iridium. Today the kilogram is the only one of the base units that is defined by an actual object. This international prototype is kept at the International Bureau of Weights and Measures in France, and there are copies in each major country.



Common Units of Mass

Unit	Relationship	Symbol
megagram	1000 kg	Mg
kilogram		kg
gram	1/1000 kg	g

Notice that 1000 kg is not kkg but Mg (actually 1 000 000 grams).

A unit of mass that is not officially SI, but is recognized as a practical unit is the metric ton (symbol t). The metric ton is equal to 1000 kg. or 1 megagram.

Finally, never use the prefix "kilo" alone when you mean kilogram.

Even though the kilogram is no longer *defined* in terms of the mass of water, for all practical problems (but not scientific problems), *1000 cm^3 (1 dm^3 or 1 litre) of water weighs 1 kilogram.*

It follows that *1 cm^3 or 1 ml of water weighs 1 gram.*

Questions:

1. Explain the basic difference between mass and weight.
2. For our purposes, are we going to differentiate between mass and weight?
3. What is the base SI unit for mass?
4. Name three common SI units of mass.
5. How many kilograms are there in 1 megagram? in 1 metric ton?
6. How many grams are there in 1 kilogram? in 1 megagram? in 1 metric ton?
7. Name a unit that is sometimes used along with the SI units for mass or weight.
8. Write the symbols for gram, kilogram, megagram, and metric ton from memory.
9. What makes the official definition of kilogram different from the other base units?
10. Besides the kilogram, how many other base units have prefixes in their names?

Lesson 2 — Conversions Within Units of Mass or Weight

Objective: You should be able to convert from one SI unit of mass to another by properly multiplying or dividing.

In lesson 1 of this chapter on mass we established that:

1000 kilograms = 1 megagram or 1 metric ton

1000 grams = 1 kilogram

Again, we will stress that to convert from a smaller unit to a larger unit we divide (move the decimal point to the left), and to convert from a larger unit to a smaller unit we multiply (move the decimal point to the right).

Examples:

1. Express 600 grams in kilograms

   a. In changing from a smaller unit to a larger unit we divide (move the decimal point to the left).

   b. 1000 grams = 1 kilogram
   Therefore, we will divide by 1000 (move the decimal point 3 places to the left).
   600 grams = 0.6 kilograms

2. Express 3.57 metric tons in kilograms

   a. In changing from a larger unit to a smaller unit we multiply (move the decimal point to the right).

   b. 1000 kilograms = 1 metric ton
   Therefore, we will multiply by 1000 (move the decimal point 3 places to the right).
   3.57 t = 3570 kg

Problems: Fill in:

1. 2000 kilograms = _____ metric tons
2. 5.75 megagrams = _____ kilograms
3. 4253 grams = _____ kilograms
4. 0.071 kilograms = _____ grams
5. 1523 kilograms = _____ megagrams
6. 2 001 532 grams = _____ metric tons
7. 25 metric tons = _____ grams
8. 3 kilograms = _____ metric tons
9. 16.2 grams = _____ kilograms
10. 0.0067 kilograms = _____ grams

Lesson 3 — Estimation and Mathematical Problems With Units of Mass or Weight

Objectives:

1. You should be able to estimate weights in the metric system.

2. You should be able to solve mathematical problems involving units of mass or weight.

In order to estimate weights in the metric system, we will first memorize the weights of a few objects that we will use as a frame of reference.

Problems:

1. Weigh yourself on a metric scale. Memorize your weight in kilograms. This will be an important reference point for future estimates of the weight of other things. (If a metric scale is not available, then multiply the number of pounds you weigh by .4536. This will give you your weight in kilograms.)

2. a. Choose some items that you can weigh on a balance scale. You might start with something as small as a paper clip and work your way up to the weight of this book.

Item	No. of Grams	No. of Kilograms

b. Memorize these weights so that they can be used as a frame of reference.

3. Matching: After completing problems 1 and 2, match the following.

___ paper clip	(a) 45 kg
___ football player	(b) 7 kg
___ jockey	(c) 5 g
___ six-pack of canned soda	(d) 55 g
___ nickel	(e) 250 g
___ small can of tuna fish	(f) 1 g
___ tennis ball	(g) 2.5 kg
___ VW Beetle	(h) 860 kg
___ cat	(i) 100 kg
___ ordinary flashlight battery	(j) 100 g

4. The front line of a football team weighed in as follows:

Player	Kilograms
L. End	93
L. Tackle	116
L. Guard	111
Center	104
R. Guard	108
R. Tackle	107
R. End	91

What is the average weight of the players on the line of this team?

5. The *range* of a set of data is often defined as the difference between the largest and the smallest number in the set. The weights of a number of compact and subcompact cars are listed below. What is the range of their weights?

Model	Kilograms
Chevrolet Vega Coupe	1132
Chevrolet Monza Towne Coupe	1213
Chevrolet Monza "S" Coupe	1261
Pontiac Astre "S" Coupe	1144
Oldsmobile Starfire "S" Coupe	1351
Buick Skyhawk "S" Coupe	1344
Toyota Corolla 2 Dr. Sedan	1007
Datsun B-210 2 Dr. Sedan	932
VW Rabbit 2 Dr. Sedan	830
VW Beetle 2 Dr. Sedan	860
Fiat 128 2 Dr. Sedan	898
Honda CVCC 2 Dr. Sedan	792
Mazda RX-3 Coupe	1073

6. What is the approximate weight of:

   a. 1 litre of water _____

   b. 5 litres of water _____

   c. 1 kilolitre of water _____

   d: 1 dm^3 of water _____

   e. 1 millilitre of water _____

7. A set of 15 pool balls weighs 255.15 g. What does each ball weigh?

8. A weight lifter made 3 lifts during a competition. They were 136 kg, 158.75 kg, and 147.42 kg. What was the average of the three lifts?

9. Suppose that you owned a field that is 2 hectares in area and one morning there was a rainfall of 1 mm. How many litres of water is this? Approximately how many kilograms would it weigh? What generalization could a farmer make from this problem to help him determine how much water to use to irrigate his fields?

10. Weigh as many items as time permits and record the results in either grams or kilograms. For example, in a building class you might weight your individual tools, some pieces of lumber of different sizes, a red brick, etc.

Lesson 1 **Tire Pressure**

Objectives:

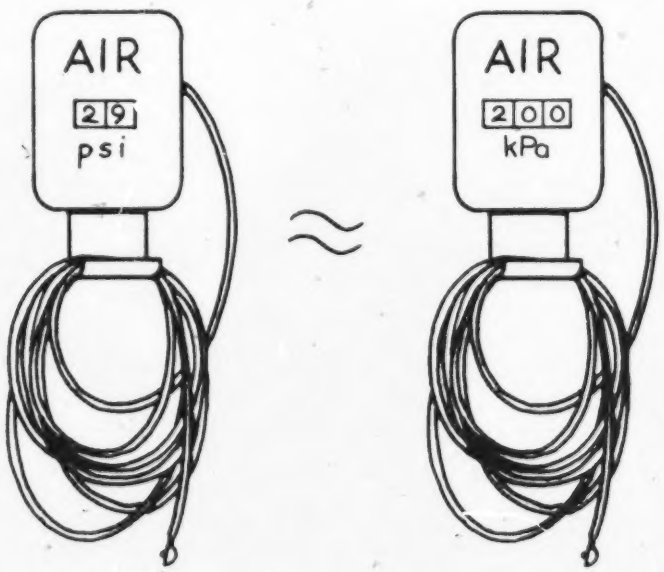
1. You should be able to state the base SI unit that will be used for pressure and write its symbol.

2. You should be able to state the unit used for tire pressure and write its symbol.

3. You should be able to state the two given tire pressures from memory, so that they can be used as a frame of reference.

The customary unit that we have used for tire pressure is pounds per square inch. The unit that will replace pounds per square inch is not going to be kilograms per square centimetre as you might think, but it will be the **pascal** (symbol Pa). Tire pressures will be measured in **kilopascals** (kPa)

Suppose we assume that 29p.s.i. is the normal tire pressure used in normal tires on a medium-sized car. This pressure is just about 200 kPa.



The recommended tire pressure on a modern 26-inch, 5-speed bike is 55 pounds per square inch. Therefore, the recommended tire pressure is 380 in kilopascals.

Questions:

1. What is the SI base unit used for pressures?
2. What is the symbol for this unit?
3. What is the unit that will be used for tire pressure?
4. What is the symbol for this unit?
5. From memory, state the number of kilopascals of air pressure in the car tire and in the bicycle tire mentioned in this lesson.
6. Estimate the number of kilopascals in a tire that has 40 p.s.i.

Lesson 2 — Speed

Objectives:

1. You should be able to state the SI unit that will be used for speed and write its symbol.

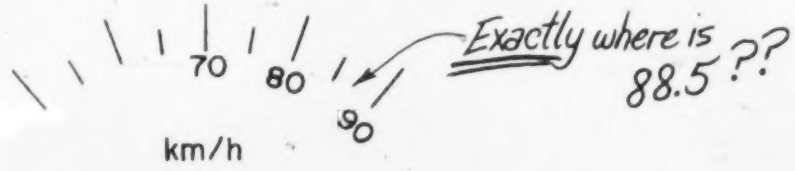
2. You should be able to state the unit that will be used for car speed and write its symbol.

3. You should be able to state from memory the two given speeds, so that they can be used as a frame of reference.

The customary unit that we have used for speed is miles per hour. The unit that will replace miles per hour is **kilometres per hour**. (km/h). The actual SI unit of speed or velocity is **metres per second** (m/s).

Two common speed limits for which we should learn the equivalent number of kilometres per hour are 25 miles per hour (most built-up areas) and 55 miles per hour (highways).

Unfortunately, when these are converted they do not correspond to nice, neat multiples of 5, and most car speedometers are marked in multiples of 5. Since 55 miles per hour converts to about 88.5 kilometres per hour, then we would have to approximate where 88.5 kilometres per hour is located on the speedometer.



Now 25 miles per hour is not too difficult to contend with on a metric speedometer, because it comes to approximately 40.2 kilometres per hour. This can easily be called 40 km/h.

Therefore the two speed limits that you should memorize are 40 km/h and 90 km/h.

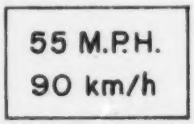
Questions:

1. What is the base SI unit for speed, and what is its symbol? _____

2. What is the unit that will be used for car speeds? What is its symbol? _____

3. Two common road speed limits are _____ km/h for town or city driving and _____ km/h for highway driving.

4. A speed-limit sign is doubly marked:



If two different drivers are driving steadily at the speed limit, and one has a speedometer marked in miles per hour and the other has a speedometer marked in kilometres per hour, are they traveling at the same speed? Who is traveling faster?

_____

5. If your speedometer reads 50 km/h and you are going through a school zone, are you speeding? _____

6. At 70 km/h, would you be speeding on the average highway? _____

Lesson 3 **Horsepower**

Objectives:

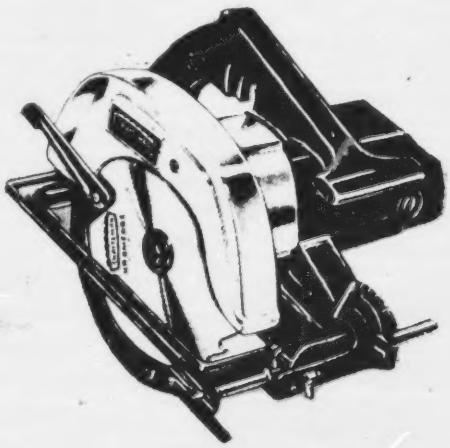
1. You should be able to state the SI unit for power and write its symbol.
2. You should be able to state the unit that will be used in place of horsepower and write its symbol.
3. You should memorize the four given examples so that they may be used as a frame of reference.

"Power" means the rate at which work is being performed. The power of a car, for example, has been measured in the unit called horsepower.

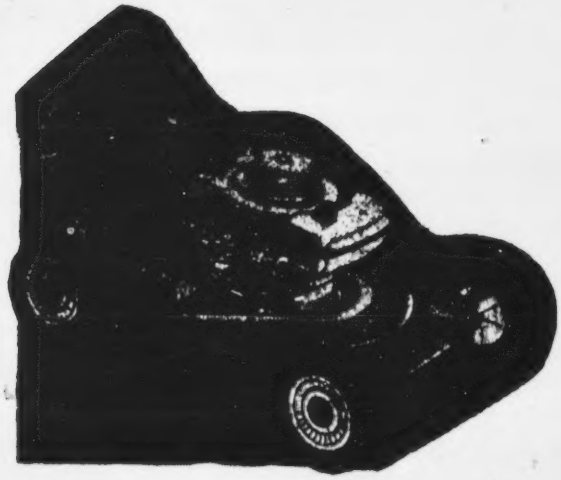
The SI unit for power is the **watt** (symbol W). The unit that will replace the horsepower is the **kilowatt** (kW), which is, of course, equal to 1000 watts.

It happens that there is a very simple relationship between kilowatts and horsepower. *A kilowatt is almost exactly equal to three-fourths of a horsepower.*

Now here are examples of four common machines. If you memorize their power outputs, this will give you a frame of reference for judging the power of other machines.

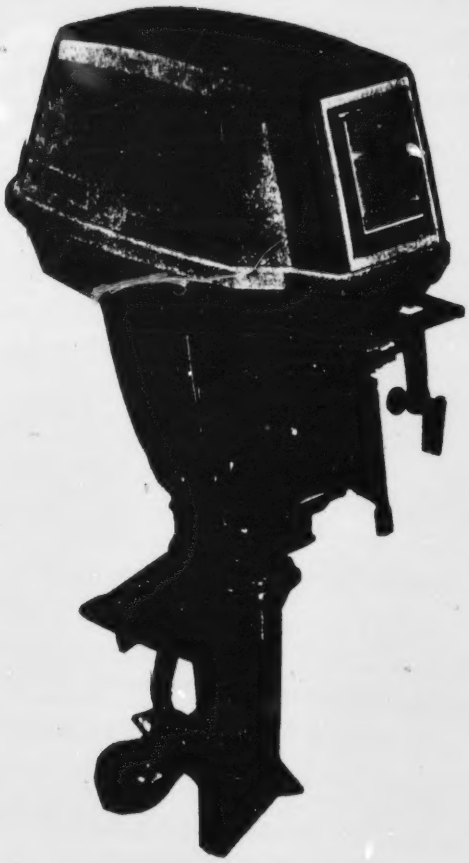


A 7-inch circular saw develops about 1¾ horsepower. This is approximately 1.3 kW.



A 3 horsepower lawnmower engine develops approximately 2.24 kW of power.

A 40 horsepower outboard motor is rated at about 30 kW.



A Ford Pinto 2000 cc engine develops 100 horsepower at 5600 rpm. This is about 75 kW. (Note that car manufacturers use cc in place of cm^3).

Questions:

1. What is the SI unit for power? What is its symbol?

2. What unit will be used in place of horsepower? What is its symbol?

3. What is the relationship between 1 kilowatt and 1 horsepower?

4. State from memory, the approximate number of kilowatts developed by the tools described: 7-inch circular saw, the 3-horsepower lawnmower, the 40 hp outboard motor, and the 2000 cc Ford Pinto engine mentioned in this section.

5. If a car engine develops 300 horsepower, approximately how many kilowatts is this?

6 What would be the approximate power rating of a 4 hp lawn mower?

APPENDIX

BRITISH STANDARDS FOR LUMBER

(cross sections)

All dimensions are in millimetres.

THICKNESS	WIDTH								
16 x	75	100	125	150					
19 x	75	100	125	150					
22 x	75	100	125	150					
25 x	75	100	125	150	175	200	225	250	300
32 x	75	100	125	150	175	200	225	250	300
36 x	75	100	125	150					
38 x	75	100	125	150	175	200	225		
40 x	75	100	125	150	175	200	225		
44 x	75	100	125	150	175	200	225	250	300
50 x	75	100	125	150	175	200	225	250	300
63 x		100	125	150	175	200	225		
75 x		100	125	150	175	200	225	250	300
100 x		100		150		200		250	300
150 x				150		200			300
200 x						200			
250 x								250	
300 x									300

STANDARD LENGTHS — Metric Softwood Lumber

Length in metres

1.8 m	3.0 m	4.2 m	5.4 m
2.1 m	3.3 m	4.5 m	5.7 m
2.4 m	3.6 m	4.8 m	6.0 m
2.7 m	3.9 m	5.1 m	6.3 m